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## Teacher self-efficacy, content and pedagogical knowledge, and their relationship to student achievement in Algebra I

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**TEACHER SELF-EFFICACY, CONTENT AND  
PEDAGOGICAL KNOWLEDGE, AND THEIR RELATIONSHIP  
TO STUDENT ACHIEVEMENT IN ALGEBRA I**

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**A Dissertation**

**Presented to**

**The Faculty and Staff of the School of Education**

**The College of William and Mary in Virginia**

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**In Partial Fulfillment**

**Of the Requirements for the Degree**

**Doctor of Education**

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**By**

**Antonia M. Fox**

**March 26, 2014**

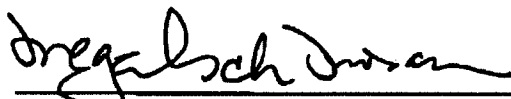
**TEACHER SELF-EFFICACY, CONTENT, AND  
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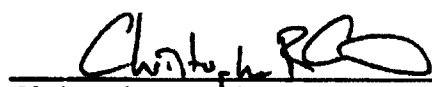
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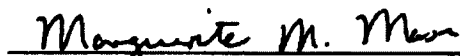
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## Dedication

To the loving memory of my Mum, Tina Catella.  
I love you and miss you every day!

To my Dad, Tony Catella, with thanks and great love for always setting  
the example and for supporting all of your children in every way.  
Thanks for always making us laugh!  
Your love and selfless care for Mum is an example for all of us!

To my amazing husband, Reggie  
This is as much yours as it is mine. Thank you for your  
unconditional love, support and encouragement. Fried Apples!

To my sweet sons, Joshua and Aaron  
This is for you...May you always love your God, value your family,  
treasure your education, honor your country,  
and be of service to others. I love you!

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*"I've heard it said that people come into our lives for a reason, bringing something we must learn. And we are led to those who help us most to grow if we let them. And we help them in return. I know I'm who I am today, because I knew you."*

Lyrics from "For You" from *Wicked*, The Musical

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## Abstract

The purpose of this quantitative study was to explore the relationship between teacher self-efficacy beliefs and the level of student achievement their students obtain as evidenced by the Algebra I Virginia Standards of Learning (SOL) assessment. This study also explored teachers' mathematics content knowledge, mathematics pedagogical knowledge, and the relationship of each of these to their self-efficacy beliefs as teachers, and to student achievement. Finally, the study explored whether there were significant differences between teachers who teach Algebra I at the middle school level versus those who teach Algebra I at the high school level in each of the four variables under study.

A strong correlation was found between teacher self-efficacy and mathematics pedagogical knowledge. The more mathematics pedagogical knowledge a teacher possesses, the higher his or her self-efficacy is likely to be. Teachers with high self-efficacy tend to exhibit behaviors in the classroom that lead to greater student outcomes. While this study did not find a significant statistical relationship between teacher self-efficacy, student achievement or mathematics content knowledge, these may be relationships worthy of future study.

This study suggests that school leaders can impact student outcomes by providing high quality, on-going professional development for teachers in the area of mathematics pedagogy. Teaching teachers how to teach math will increase teacher's self-efficacy which may lead to higher goals and greater effort, persistence, and resilience. These, in turn may ultimately impact the overall achievement of the students.

**Teacher Self-Efficacy, Content and Pedagogical Knowledge, and Their  
Relationship to Student Achievement in Algebra I**

## **CHAPTER 1: THE PROBLEM**

### **Statement of the Problem**

Algebra I is a unique course to involve in a research study for several reasons:

1) it is a gateway course – a high school diploma cannot be awarded in the state of Virginia without a student taking and passing the Algebra I course and the End-of-Course (EOC) SOL assessment; 2) Algebra I is taught at both the middle school and high school level; and 3) math progress, particularly Algebra I, is an area of concern for researchers and educators nation-wide and within the context of global achievement and preparation. One way to address the concerns about student's mathematics achievement is to ensure that teachers who believe that they can impact student learning are standing before our students.

The purpose of this study is to build upon the research base in the area of teacher self-efficacy and student achievement in the Algebra I classroom, and to determine if there are statistically significant differences in these variables at the high school or middle school level, and in terms of the level of mathematics content and pedagogical knowledge a teacher possess. With this information in hand, school leaders can develop professional development that centers about the specific needs of teachers. Ultimately, this method impacts the achievement of students in Algebra I.

Educational administrators, parents, and school leaders want every teacher to be able to say with confidence "As a teacher, I know that I can positively impact the learning of my students." Teacher self-efficacy is defined as a teacher's belief in his or her capability to organize and execute the courses of action required to successfully accomplish specific teaching tasks in a particular context (Bandura, 1997; Tschannen-

Moran, Hoy & Hoy, 1998). The concept of self-efficacy is an important one to study as it deeply impacts teachers' behaviors, such as motivation, goals, persistence, and resilience, as well as their performance and attitudes toward their students (Erdem & Demirel, 2007).

Teacher content and pedagogical knowledge are also important elements in understanding the complex nature of teaching. Not only do teachers need to believe they can have an impact on the learning of their students, but they must have a thorough understanding of the content they teach, as well as a firm grasp of which pedagogical method would be best utilized to teach a particular concept. Mathematics content knowledge is the knowledge a teacher has of various mathematics concepts and it is acquired through formal education (Cancoy, 2010). Mathematics pedagogical knowledge is the skills the teacher uses to impart specialized knowledge or content related to their subject area. Every student would do well to have a teacher standing before them who believes in their ability to positively affect the outcome of his or her learning and achievement.

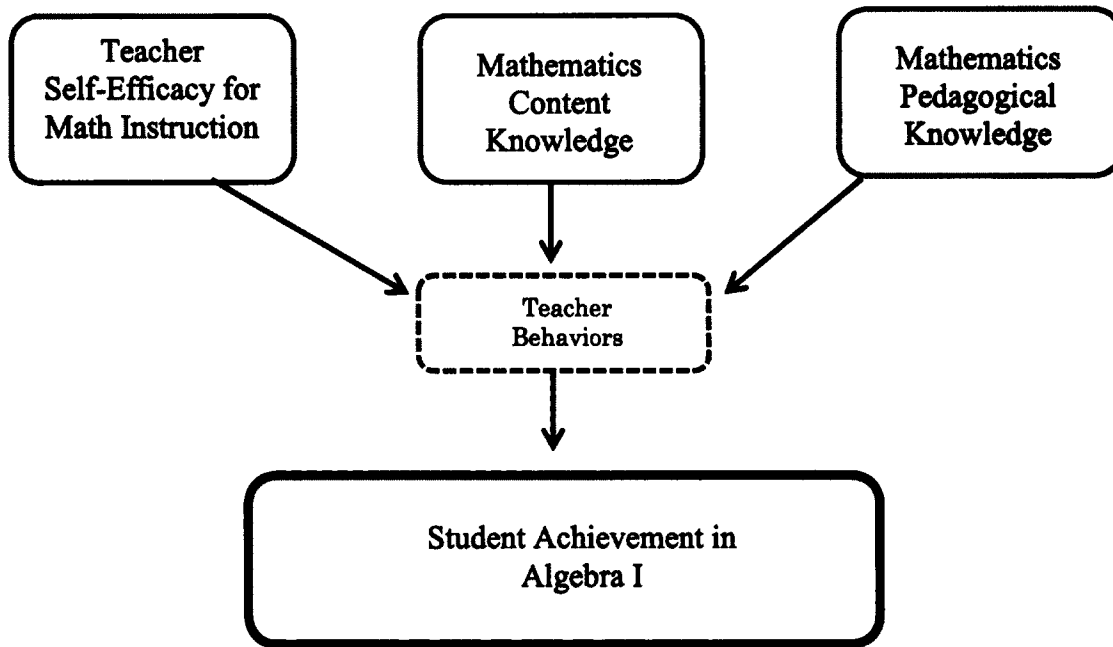


Figure 1. Conceptual Framework: Teacher Self-Efficacy, Content Knowledge, Pedagogical Knowledge and Student Achievement in Algebra I

### **Mathematics Achievement**

In this era of educational accountability, schools and educational leaders are continually looking for better ways to assist students in meeting these various learning outcomes, as well as how to discover ways to meet the ever-increasing demands of the No Child Left Behind Act of 2001 (NCLB). NCLB has strict measures by which schools are judged each year. Many of these measures are based on achievement tests that students are required to pass to demonstrate mastery of state-approved curricula.

The problem addressed in this study relates to recent reports from the Trends in International Mathematics and Science Study (TIMSS) which have highlighted the fact that American students perform more poorly than their peers in the rest of the world on

mathematics assessments. The most recent TIMSS study ranked the United States tenth in math achievement, as compared to other developed countries (National Center for Educational Statistics, 2011). Educators are pondering how to move America's students back into the forefront of mathematics achievement.

One recommendation that came from a 2002 Southern Regional Education Board (SREB) study was to challenge students at a higher level prior to entering the ninth grade (Bottoms, 2002). Taking Algebra in the middle grades leads to enrollment in higher-level math courses in high school and has not been found to increase failure rates (Bottoms, 2002).

In the state of Virginia, there has been a strong push to have all students complete their study of Algebra I by eighth grade, the end of middle school for most students. This has placed formidable anxiety on middle school educators as they have had to find teachers who are not only certified, but are skilled enough to teach Algebra I to middle school students. Unfortunately, not every student meets the benchmark of completing Algebra I by the end of middle school, so Algebra I is one of the few courses in Virginia taught at both the middle and high school level.

Additionally, Algebra I is a course which is required for all students to pass with a grade of D or better, and receive a passing score on the End-of-Course (EOC) Standards of Learning (SOL) assessment in order to receive a standard or advanced diploma. Thus failure in either the coursework or the assessment of Algebra I prohibits graduation.

Given the importance of having students be successful in Algebra I, the mandates of NCLB, and the renewed push to have students be competitive in a global market, it is imperative to have teachers who are motivated by the belief that they can reach every



student in these Algebra classes. This study will investigate the extent to which a teacher who stands before students with the belief that he or she can get even the most unmotivated of students to pass Algebra I has an impact on the achievement of students.

### **The Role of Teachers**

In recent years, the accountability movement has intensified the attention given to the impact teachers have on the students in America's classrooms. Bandura (1997) asserted that "the task of creating learning environments conducive to the development of cognitive competencies rests heavily on the talents and self-efficacy of teachers" (p. 240). Teachers' talents are expressed in many different ways; from the style of teaching they employ, to the effort they devote to their craft, the depth of their content knowledge, or to the manner in which they interact with students. However, what remains consistently true about teachers is the key role they play in student outcomes.

The research evidence that supports the important role of the teacher to student learning is plentiful. Wright, Horn, and Sanders (1997) found that the single most dominant factor affecting student academic gain is the teacher. Evaluation of numerous empirical studies found that the teacher made up 30% of the variance of determining what influences learning the most (Hattie, 2008). If a student has a high performing teacher for just one year, the student will attain an advantage over his or her peers that will last for several years (Stronge, Ward, Tucker, & Hindman, 2008). Haycock (1998) wrote "the difference between a good and a bad teacher can be as much as a full level of achievement in a single school year" (p. 3).

Meanwhile, students who are assigned to several ineffective teachers in a row have significantly lower gains in achievement than those who are assigned to several

highly effective teachers in sequence (Sanders & Rivers, 1996). Strong teachers appear to be effective with students of all achievement levels, regardless of the level of heterogeneity in their classrooms (Wright, Horn, & Sanders, 1997). Teachers are crucial to students' opportunities to learn and substantial differences in mathematics achievement of students are attributable to differences in teachers (National Mathematics Advisory Panel, 2008).

### **Teacher Self-Efficacy**

Given the impact of the teacher has on the learning of the student, how can school leaders support teachers in guiding young minds? Teacher self-efficacy is defined as a teacher's belief in his or her capability to organize and execute the courses of action required to successfully accomplish specific teaching task in a particular context (Bandura, 1997; Tschannen-Moran et al., 1998) or the extent to which teachers believe they have the capacity to affect student performance (Ashton, 1984). Teacher self-efficacy impacts the teacher's motivation, goals, persistence, and resilience, as well as the performance and attitudes of the teacher toward his or her students (Erdem & Demirel, 2007). Among researchers and educators, teacher efficacy has been consistently and positively associated with factors of interest, such as student achievement (Wheatley, 2002). Previous studies have explored the impact of levels of efficacy on teacher effectiveness and have concluded that self-efficacy is a critical component of effective teaching and can increase student achievement (Tschannen-Moran, et. al, 1998).

Teacher self-efficacy manifests itself in the actions of the teacher. It is the teacher's behaviors in the classroom that ultimately influence the achievement of students. Ginott (1975) wrote, "I've come to the frightening conclusion that I am the

decisive element in the classroom” (p. 92). Teachers in today’s public school classrooms are expected to educate every student who enters their classroom, regardless of the student’s personal abilities, attitudes, or other confounding factors that might influence individual learning; therefore, it is important to study the behaviors of teachers who have high-self efficacy beliefs and who have impacted student achievement in a constructive manner.

Research indicates that teachers who are highly efficacious exhibit behaviors that have a positive impact on the classroom such as the amount of time they put into teaching, the goals they set, the level of accomplishment to which they aspire, and the persistence they exhibit in the face of challenges (Ashton & Webb, 1986; Tschannen-Moran et al., 1998). These teachers tend to exhibit more enthusiasm, zeal, and commitment to teaching (Allinder, 1994), and are more likely to exhibit more positive attitudes toward teaching (Guskey, 1981). Specifically, what are some of the behaviors of teacher with high self-efficacy beliefs? Table 1 outlines some of these behaviors, which will be discussed in more detail in Chapter 2.

The impact teachers and their beliefs have on student learning is both an interesting and powerful idea to investigate and one that warrants deeper probing. While a “substantial body of research suggests that teacher beliefs and values about teaching and learning affect their teaching practices” (Stipek, Givvin, Salmon, & MacGyvers, 2001, p. 213), and teaching practices in-turn affect student outcomes, the link between teacher self-efficacy and student achievement has not been the focus of many contemporary studies. There is a distinct need to produce contemporary research that would contribute to the body of work about this valuable construct. The majority of the

studies that demonstrate an association between teacher self-efficacy and student achievement are more than 20 years old.

**Table 1**

*Sample classroom behaviors of teachers with high self-efficacy beliefs*

| <b>Behavior</b>   | <b>Researchers</b>                          |
|---|---|
| Less likely to use seat-work to control students                          | Ashton & Webb, 1986                         |
| Engage students in activity-based learning                                | Enochs, Scharmann, & Riggs, 1995            |
| Exhibit high levels of planning and organization                          | Allinder, 1994                              |
| Sustain on-task behaviors resulting in classes focused on learning        | Allinder, 1994<br>Podell & Soodak, 1993     |
| Maintained high academic standards  | Allinder, 1994                              |
| Utilize management strategies that stimulate student autonomy             | Ross, Hogaboam-Gray, & Hannay, 2001         |
| Attend more closely to low-ability students' needs                        | Ross et al, 2001                            |
| Modify student ability perceptions  | Ross et al, 2001                            |
| Communicate clear expectations to students                                | Allinder, 1994                              |
| Demonstrated a positive effect in shaping student attitudes toward school | Rose & Medway, 1981                         |
| Exhibit positive relationships with students                              | Rose & Medway, 1981                         |
| Persists longer during a lesson with students who are struggling          | Allinder, 1984                              |
| Be less critical of a student who has made an error                       | Ashton & Webb, 1986<br>Gibson & Dembo, 1984 |
| Less likely to refer students to special education                        | Meijer & Foster, 1998                       |

While these studies provide a strong foundation, there is currently a strong interest among educational researchers to garner more informed quantitative data to further explore the connection between teacher self-efficacy and student achievement. Because all leaders and educators want students to be successful and because current NCLB legislation requires schools to demonstrate achievement, there is a strong desire to

articulate the relationship between the self-efficacy of teachers and student achievement. There are no research studies that exclusively examine the relationship between teacher self-efficacy and student achievement as measured by the Virginia Standards of Learning (SOL) End-of Course (EOC) assessments. Furthermore, because Algebra I is the only course to have an End of Course assessment that is given at both the middle and the high school level, an interesting opportunity exists to gather more information about what is occurring with respect to student achievement and teacher self-efficacy beliefs at these two distinct levels.

Further exploring topics that can assist students in being better educated and more prepared for the 21<sup>st</sup> Century should engage any educator. The beliefs a teacher possesses about his or her ability to impact learning are profound in that it effects not only the actual classroom delivery of content, but the planning and assessment of instruction, as well as the actions of the teacher to influence and encourage student's in the learning process.

### **Content and Pedagogical Knowledge in Mathematics**

The art of teaching is complex and student learning is the result of many different constructs interacting simultaneously. Teacher self-efficacy is one such construct, but there are others that can also have an impact on the overall achievement of students. A teacher's mathematics content knowledge and mathematics pedagogical knowledge are crucial elements that influence how a teacher perceives his or her ability to impact student outcomes. "A deep understanding of mathematics concepts may enable teachers to access a broad repertoire of strategies for explaining and representing mathematical content to their students" (Krass, Brunner, Kunter, Baumert, Neubrand, Blum & Jordan,

2008). Evidence from previous studies indicates that students' learning gains in mathematics may be predicted by the knowledge a teacher has of mathematics (Hill, Rowan & Ball, 2005; Swars, Hart, Smith, Smith & Tolar, 2007; Utley, Moseley & Bryant, 2005). Teachers with higher levels of content knowledge, more positive attitudes toward math, and stronger self-efficacy are better able to produce higher student achievement gains than teachers with lower levels (Evans, 2011). In order to ensure students learn mathematics from both a conceptual and procedural standpoint, teachers must demonstrate comprehension of mathematics in two domains: 1) content knowledge or the understanding of the mathematics, and 2) pedagogical knowledge or the teacher's knowledge of how to teach various mathematics concepts to students.

**Mathematics content knowledge.** Mathematics content knowledge is the knowledge a teacher has of various mathematics concepts and it is acquired through formal education (Cancoy, 2010). How well do the teachers who are teaching the young minds in their classrooms understand the concepts behind the material they introduce, explain, and assess? In most American mathematics classrooms, teachers spend the majority of their time teaching students the mechanics of procedural problem solving. Teachers with strong content knowledge can and will explain to students the conceptual reasoning behind the problem, not just demonstrate the step-by-step process required to solve the problem. Krauss et. al (2008) explained this idea very succinctly:

Imagine you are a mathematics teacher. A student puts his hand up and says: 'I don't understand why  $-1$  times  $-1$  equals  $+1$ . I know it's the correct result, but it makes no sense to me. Why does multiplying two negative numbers give you a positive number?'

In order for our mathematics students to move toward true and deep understanding of mathematics, a teacher must be able to answer the student's question, as well as explain the rationale for the problem in a manner in which the student can understand.

Policymakers have recently made the teacher's knowledge of the subject matter a focal point (Hill, Rowan, & Ball, 2005). "To provide students with 'highly qualified teachers,' the NCLB Act requires teachers to demonstrate subject-matter competency through subject specific majors, certifications, and other means" (Hill et al., 2005, p. 371). In the past, most teachers majored in education, and possibly held a minor in a specific content area such as mathematics. The current requirement is that teachers major in an area such as mathematics and receive a teaching endorsement from a college or university. This equates to having more teachers in the classroom with more extensive mathematics content knowledge, if the measure of this knowledge is based on the number of mathematics courses a teacher has taken.

**Mathematics pedagogical knowledge.** Mathematics pedagogical knowledge differs from mathematics content knowledge. The National Board for Professional Teaching Standards (2011) defines pedagogical knowledge as the skills teachers use to impart the specialized knowledge or content of their subject area. In order to respond to student questions appropriately, teachers not only need to understand the mathematical concepts underlying the question, they also need to know how these concepts can best be explained to students (Krauss et al., 2005).

Since the process of learning is influenced by the teacher, it is important to understand how teachers explain various concepts to students, what they emphasize, and

what they do not; and ways they choose to help students understand (Even, 1993).

Shulman (1986) defined pedagogical content knowledge as including “knowledge on how best to represent and formulate the subject to make it comprehensible to others” (pp. 9-10). For example, teachers with varying levels of pedagogical knowledge might well introduce or explain irrational numbers or the slope of a line to students in Algebra I differently.

Teachers typically take several methods courses in college to prepare them for the classroom and once they are in the classroom, they undergo professional development to further enhance the level of pedagogical knowledge they possess. They learn various ways of explaining concepts to students by having students ask questions or by seeing other teacher’s model practices for them.

In sum, the three constructs under study are all postulated to be related to student achievement in Algebra I classes as well as to influence each other. Teacher self-efficacy belief is an important concept in the understanding of teachers’ motivation, thoughts, decisions, feeling, behaviors, performance and attitudes toward their students (Erdem & Demirel, 2007). The degree of knowledge a teacher has in terms of both content and pedagogy can impact student outcomes. This is critical information because it can provide a guide as educators work with pre-service teachers in designing their course of study as they prepare to enter the field of education. It also places school leaders in a position to better plan professional development, enhance teacher mentor programs, and provide resources to assist in the development of practicing teachers. The more we know about a teacher’s sense of self-efficacy, the level of mathematics content and pedagogical



knowledge, the more we know about them as a teacher, and how their behaviors will ultimately impact the learning of students.

### **Research Questions**

This investigation proposes the following research questions in a sample of middle school and high school teachers of Algebra I in several school divisions in Virginia.

1. To what extent are teacher self-efficacy beliefs for mathematics instruction related to student achievement in Algebra I?
  - a. Do teacher self-efficacy beliefs differ significantly between teachers who teach Algebra I to students in middle and high schools?
  - b. To what extent are there differences in the relationship between teacher self-efficacy beliefs and student achievement based on whether teachers teach Algebra I to students in middle or high schools?
2. To what extent are Algebra I teachers' self-efficacy beliefs for mathematics instruction related to mathematics content knowledge (as assessed by certification type)?
  - a. Do Algebra I teachers' mathematics content knowledge differ significantly based on teaching students in middle or high schools?
  - b. To what extent is Algebra I teachers' mathematics content knowledge correlated to student achievement in Algebra I?

3. To what extent are Algebra I teachers' self-efficacy beliefs related to their level of mathematics pedagogical knowledge?
  - a. Does teacher mathematics pedagogical knowledge differ significantly based on teaching Algebra I to students in the middle school versus the high school?
  - b. To what extent is Algebra I teachers' mathematics pedagogical knowledge correlated to student achievement in Algebra I?

### **Significance of the Study**

In a time of ongoing educational reform where the focus is on educating all students using standards-based curriculum, the need for highly-qualified, highly effective teachers is imperative. Teachers are besieged by new and ongoing demands from increased workloads, shifting policies and expectations, to societal demands and evolving best practices. The beliefs teachers hold about their capabilities in the face of ever pressing challenges plays a strong role in student learning (Tschannen-Moran & Woolfolk-Hoy, 2001). This study is significant on two levels: 1) it will expand and update the research base associated with the relationship between teacher self-efficacy and student achievement; and 2) it will provide for school leaders insight in the abilities and needs of the teachers who are ultimately responsible for the learning of students in mathematics.

While teacher self-efficacy is a well-received construct, there has been relatively little research completed tying it to student achievement measures such as those mandated by NCLB, and even fewer specific to the critical area of mathematics instruction. Much of the existing literature base correlating teacher self-efficacy beliefs

to student achievement is more than twenty-years old. Of the seminal works that established a relationship between teacher self-efficacy and student achievement, none were published later than 1992. While there are many studies published after 1992 involving teacher self-efficacy, none of them directly ties the construct to student achievement. This study will make a significant contribution to the research literature, both by setting it in the context of an important academic realm, and by using a measure of student achievement aligned with rigorous state standards.

Therefore, there is a gap that needs to be filled and a plethora of opportunities in which to investigate the correlation between teacher's self-efficacy beliefs and student achievement. In the state of Virginia, all students are required to take Standards of Learning (SOL) assessments at various times in their elementary and middle school careers, as well as at the end of specific high school courses. There are no current research studies that link teacher self-efficacy to student achievement on any Virginia SOL assessment. Additionally, there are strands of research that would prove beneficial to study in relation to student achievement, teacher self-efficacy and mathematics instruction.

Teachers are crucial to the student's opportunities to learn and to the learning of mathematics, and the research literature states time after time the knowledge and skills of the teacher dominates the effects on student achievement (National Mathematics Advisory Panel, 2008). Given this, it is useful to know as much as we can about the teachers who stand before our children. Does the teacher in the Algebra I classroom believe that he or she can make a difference in the achievement of every student who walks through the door, regardless of the factors that individualize each student? Can the

mathematics teacher effectively solve problems for students? Can he or she explain why the answer is what it is? Students need to understand not only how to get the right answer but why it is the right answer. What can we learn from teachers who teach Algebra I to middle school students, who are typically more motivated and more capable than high school students taking algebra somewhat later than their peers? Given the importance of having students be successful in Algebra I, the mandates of NCLB, and the renewed push to have students be competitive in a global market, it is imperative to have the right teachers in the right classrooms and this study presents educational leaders with a way to garner this information.

### **Definition of Terms**

*Content Pedagogy* - refers to the pedagogical (teaching) skills teachers use to impart the specialized knowledge/content of their subjects (area) (National Board for Professional Teaching Standards, 2011).

*High School* – grades 9, 10, 11 and 12

*Mathematics Content Knowledge* – the mathematics knowledge used to carry out the work of teaching mathematics (Aerni, 2008; Hill, Rowan, & Ball, 2005).

*Mathematics Pedagogical Knowledge* – set of special attributes or skills that allow teachers to transfer knowledge of content to their students (Aerni, 2008; Geddis, 1993).

*Middle School* – grades 6, 7, 8

*Secondary School* – grades 6, 7, 8, 9, 10, 11 and 12

*Self-efficacy* – beliefs in one's capabilities to organize and execute the course of action required to produce given attainments (Bandura, 1997).

*Self-efficacy beliefs* –an individual’s belief that he or she can do something under a given set of circumstances (Bandura, 1997).

*Standards of Learning (SOL)* – Rigorous academic standards, set by the Commonwealth of Virginia, and measures achievement through annual SOL tests and alternative and alternate assessments (Virginia Department of Education, 2011).

*Teacher Self-Efficacy* – a teacher’s belief in his or her capability to organize and execute the course of action required to successfully accomplish a specific teaching task in a particular context (Bandura, 1997; Tschannen-Moran et al., 1998).

## **CHAPTER 2: LITERATURE REVIEW**

### **Introduction**

One of the most valuable resources public education has is its teachers. Teachers have a profound and lasting impact on the learning and achievement of our students, and in this era of accountability and high stakes testing, investigating the construct of self-efficacy is a worthy venture when working to help all students' achieve. Recent research suggests that the quality of a teacher is the most important predictor of student success (Darling-Hammond, 1998). Teachers are preparing students for federal, state, and locally mandated assessments, heightened graduation requirements, a competitive global marketplace, all the while continuing to find innovative and rigorous ways to keep students engaged in order to produce desired student learning outcomes. To keep pace with these changes, teachers are finding it necessary to reflect on their content knowledge, instructional practices and methods in an effort to meet the needs of each student (Darling-Hammond & McLaughlin, 1995).

The purpose of this study is to expand upon the research base in the area of teacher self-efficacy and its relationship to student achievement, mathematics content knowledge and pedagogical knowledge of the Algebra I teacher. It is important to understand the construct of teacher self-efficacy as it relates to Bandura's Social Cognitive theory and how teacher behavior is influenced by self-efficacy beliefs. Since there is limited contemporary research available in this particular area of study, this literature review seeks to provide the reader with overview of what research is available in support of the positive correlation that exists between teacher self-efficacy and student achievement, especially in mathematics. Additional information provided in this

literature review expounds upon mathematics content knowledge and pedagogical knowledge of teachers of mathematics.

### **Bandura's Social Cognitive Theory and Self-efficacy**

Bandura's (1977) Social Cognitive Theory (SCT) is a major theoretical base for the construct of self-efficacy. The theory purports that humans are capable of forming expectations which influence subsequent performances. SCT theory asserts that people make causal contributions to their own psychosocial functioning through mechanisms of personal agency. There is little incentive or motivation to act in life unless people believe they can produce desired outcomes by their actions. Beliefs of personal efficacy are powerful and central to our pathways of humanness.

Because personal efficacy beliefs are explicitly self-referent in nature and directed toward perceived capabilities given specific tasks, they are powerful predictors of behavior (Bandura, 1997; Henson, 2001). Bandura hypothesized that people's behavior is determined not only by their generalized beliefs about action-outcome relationships (a beliefs that certain behaviors can lead to certain outcomes), but also by their sense of self-efficacy (a belief that they have the requisite skills to produce those outcomes) (Anderson et al., 1988).

Social cognitive theory assumes that people are capable of human agency, or intentional pursuit of courses of action, and that such agency operates in a process called triadic reciprocal causation (Henson, 2001; Fives, 2003; Lynch, 2007). Reciprocal causation is a multidirectional model that shows the triadic interactions of the environment, personal factors, and behaviors.

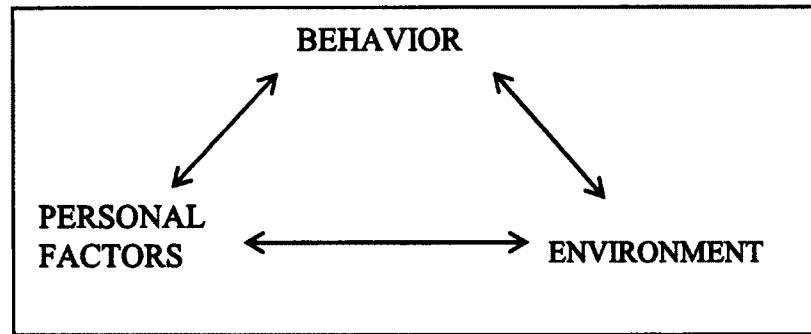


Figure 2. Model of the relationship between three classes of determinants in Bandura's conceptions of triadic reciprocity (Bandura, 1997)

Bandura asserted that we are not products of our environments or our biology exclusively; rather, we are the compendium of the dynamic interplay between the external (environment), the internal (biology) and our choices (behaviors). As people, we move through our life experiences and develop expectations about future situations from these experiences and develop beliefs about how we might also be able to cope with various situations.

Bandura (1997) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). These beliefs of personal competence affect behavior in several ways – they influence the choices individuals make and the course of action they pursue (Pajares, 1996). Bandura (1997) contended that humans observe other humans and develop self-efficacy for a task, which leads to persistence, effort, and eventual task execution (Tschannen-Moran et al., 1998). Efficacy beliefs also help to determine how much effort people will expend on an activity, how long they will persevere when confronted by obstacles, and how resilient they become when faced with adverse situations – the higher the sense of efficacy, the greater the effort, persistence, and resilience (Pajares, 1996; Tschannen-Moran & Woolfolk Hoy, 2001).



As self-efficacy is contextual, it differs from other forms of self-concept such as self-confidence or self-esteem, which are personality traits or general beliefs one has about him or herself. “In comparative tests of predictive power, efficacy beliefs are highly predictive of behavior, whereas the effect of self-concept is weaker and equivocal” (Bandura, 1997, p. 11). Confidence is a nondescript term or catchword that refers to the strength of belief but does not necessarily specify what the certainty is about. People need more than just confidence or self-esteem to do well in given pursuits. Self-esteem is concerned with judgments about self-worth, and there is no relationship between one’s capabilities and one’s like or dislike of oneself. In ongoing pursuits, perceived personal efficacy predicts the goals people set for themselves and their performance attainments, whereas neither self-esteem nor confidence affects personal goals nor performance (Bandura, 1997).

Beliefs in self-efficacy differ in level, generality, and strength. Level infers that the perceived task may be deemed as simple, moderate, or difficult, while generality implies that activities are similar in degree, situations, or require similar capabilities. Strength of self-efficacy beliefs can vary – a weak or low self-efficacy belief will allow negative experiences to weaken self-efficacy and as a consequence, the person gives-up (Bandura, 1997). Conversely, those with strong self-efficacy beliefs tend to continue to strive toward accomplishment, even in the face of challenges (Bandura, 1997).

### **Efficacy Expectations and Outcome Expectancies**

It is important to note that Bandura’s SCT also proposes a secondary expectation, outcome expectancy, which is different from the efficacy expectation (Tschannen-Moran & Woolfolk Hoy, 2001). Bandura (1997) made clear the distinction that motivation is

affected by both of these expectations (Woolfolk & Hoy, 1990). The two expectations can be differentiated because individuals can believe that certain behaviors will produce certain outcomes, but, if they do not believe that they can perform the necessary activities, they will not initiate the relevant behaviors (Gibson & Dembo, 1984).

Efficacy expectations are the “individual’s conviction that he or she can orchestrate the necessary actions to perform a given task,” while outcome expectancy is the “individual’s estimate of the likely consequences of performing the task at the expected level of competence” (Bandura, 1997, p. 21). Bandura (1997) noted that “the types of outcomes people anticipate depend largely on their judgments of how well they will perform in given situations” (p. 21). There is a causal relationship that exists between efficacy beliefs and outcome expectancies – people do not visualize outcomes and then infer their abilities; they infer their abilities and then visualize the outcomes. Efficacy expectations precede and help to form outcome expectations. This relationship is depicted in Figure 3.

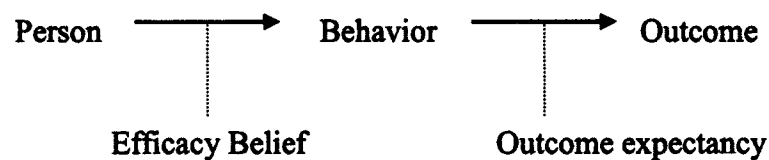


Figure 3. The conditional relationship between efficacy beliefs and outcome expectations (Bandura 1997)

### Sources of Efficacy Beliefs

Bandura (1977, 1997) postulated that self-efficacy beliefs have four principal sources of information: enactive mastery experiences that serve as indicators of capability; vicarious experiences that alter the efficacy beliefs through transmission of

competencies and comparison with attainment of others; verbal persuasions; and physiological or affective states from which people partly judge their capableness, strength, and vulnerability to dysfunction.

**Mastery Experiences.** “Mastery experiences are the most influential sources of efficacy information because they provide the most authentic evidence of whether one can muster whatever it takes to succeed” (Bandura, 1997, p. 80). When an individual finds success with a task, that individual will have the expectation that the same task will be completed with proficiency in the future; and, likewise, if the task is not completed with proficiency, the expectation for completing the task will be much lower (Bandura, 1997; Pajares, 2002; Tschannen-Moran et al., 1998). Successful, authentic mastery experiences help cultivate the beliefs an individual holds about his or her capabilities or performance – the essence of efficacy (Bandura, 1997). This has been determined to have more power than learning new knowledge or skills which may increase competence but not alter performance (Pajares, 2002).

**Vicarious Experiences.** Vicarious learning also provides efficacy information for an individual by observing the performance of others and making comparisons (Henson, 2001). Because many activities that people do (e.g., teaching) have no absolute measure of adequacy, people must appraise their capabilities in relation to the attainments or skills of others (Bandura, 1997). The extent to which the observed identifies with the person performing the identified task will play a factor in the effect on the observer’s self-efficacy (Bandura, 1997). The comparative nature of vicarious experience also leads to increases or decreases in efficacy beliefs. Assumptions that result in a person believing they have surpassed the colleague result in an increase in self-efficacy beliefs, while a

feeling of being outperformed can lead to a lowered sense of personal efficacy (Bandura, 1997). This source of efficacy development is beneficial for someone experiencing a novel task or when a person is uncertain about his or her own abilities (Pajares, 2002).

**Verbal Persuasions.** Verbal persuasions, the voiced support of those around us, provide positive sustenance as tasks are attempted or completed. They are less powerful than mastery experiences, but can support and develop self-efficacy if utilized in a realistic manner (Bandura, 1997; Fives, 2003; Pajares, 2002).

It is easier to sustain a sense of efficacy, especially when struggling with difficulties, if significant others express faith in one's capabilities than if they convey doubts. To raise unrealistic beliefs of personal capabilities, however, only invites failures that will discredit the persuaders and further undermine the recipients' beliefs in their capabilities (Bandura, 1997, p. 101).

The successful persuader cultivates people's beliefs in their capabilities while at the same time ensuring that the envisioned success is attainable (Pajares, 2002), and this will ultimately lead to a greater likelihood that the recipient will expend a greater and more sustained effort (Bandura, 1997).

**Affective or psychological states.** Affective or psychological states, such as anxiety, stress, arousal, fatigue, and mood states, play an important role in efficacy development and refer to the level of arousal that is involved during times of anticipated success and failure (Pajares, 2002). The way an individual interprets cues (e.g., anxiety prior to task completion means failure is eminent) can raise or lower efficacy levels for particular task completion (Bandura, 1997). "The level of arousal, either anxiety or excitement, adds to the feeling of mastery or incompetence" (Tschannen-Moran et al.,

1998, p. 211). For tasks that produce anxiety, exposure to mastery experiences can heighten self-efficacy beliefs and result in corresponding improvements to performance (Bandura, 1997).

### **Teacher Self-efficacy**

The impact teachers have on student learning is both an interesting and powerful idea to investigate and one that warrants deeper probing. Teacher self-efficacy is an appealing idea that has born much fruit in the field of education (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). As school leaders continue to investigate how to garner greater student outcomes, teacher self-efficacy is a construct that presents the opportunity for tangible and meaningful information in this area.

As discussed previously, numerous research studies have indicated a positive correlation between teacher self-efficacy and student outcomes, such as achievement (Armor, Conroy-Oseguera, Cox, King, McDonnell, Pascal, Pauly, & Zellman, 1976; Ashton & Webb, 1986; Berman, McLaughlin, Bass, Pauly, Zellman, 1977; Anderson, Greene, & Loewen, 1988; Ross, 1992). As a construct, teacher self-efficacy has also been heavily correlated to specific teacher behaviors. Teachers who have higher self-efficacy beliefs exhibit behaviors in the classroom that are different from teachers with a lower sense of self-efficacy (Allinder, 1995).

In addition to impacting student outcomes and specific teacher behaviors, self-efficacy beliefs also affect the amount of effort teachers put into their craft, the goals they may set, the level of accomplishment to which they may aspire, and a teacher's persistence and resilience in face of challenges or setbacks (Ashton & Webb, 1986; Tschannen-Moran & Hoy, 2001; Tschannen-Moran & Woolfolk Hoy, 2007).

Teacher self-efficacy is the belief that teachers can help even the most difficult or unmotivated of students (Berman et al., 1977; Gibson & Dembo, 1984; Guskey & Passaro, 1994). It is about believing that one can make a difference even when others think it impossible or the deck seems stacked against them. Ashton and Webb (1986) stated that “teacher self-efficacy is the teacher’s belief in their ability to have a positive effect on learning” (p. 142). A more recent definition of teacher self-efficacy comes from the work of Tschannen-Moran et al. (1998) and defines teacher self-efficacy as the “teacher’s belief in his or her capability to organize and execute the courses of action required to successfully accomplish a specific teaching task in a particular context” (p. 233).

Even though the construct of teacher self-efficacy is much studied, with studies that range from its association with reading interventions to professional development practices, there are areas, such as the impact on student achievement, that are less studied and warrant additional exploration. Through empirical research, the past thirty years have seen an evolution of teacher self-efficacy theory and brought to light the relationship between teacher self-efficacy and student achievement. However, there has not been much else added to the literature base concerning this relationship in the context of contemporary education. Given the current educational climate of accountability and standards mandates, it is of vital importance to reinvigorate investigations and focus attention toward this construct and its relationship to student outcomes in order to provide valuable information to teachers, schools, and instructional leaders. “Compelling evidence has been accumulating over the past three decades revealing the relationship of teacher’s beliefs about their capability to impact students’ motivation and achievement to

important processes and outcomes in school” (Tschannen-Moran & Woolfolk Hoy, 2007, p. 944). Given this, there is a distinct need to enrich the empirical evidence line demonstrating the impact this construct has on student learning and expand its use in contemporary education.

The construct of self-efficacy extends into the educational realm and has been the focus of many studies in a variety of subject areas and with many varying contexts. Even with this formative exposure across disciplines, little attention has been given to the significant relationship teacher self-efficacy holds with student outcomes such as achievement. “The enduring confidence that many scholars, reformers and teacher educators have had in teacher efficacy is due to the fact that teacher efficacy has been consistently and positively associated with factors of interest, such as student achievement” (Wheatley, 2002, p. 6).

More than thirty years ago, researchers from the RAND organization added two questions to a survey instrument that garnered powerful results (Tschannen-Moran et al., 1998). These two questions, *When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment* (RAND Item 1) and *If I really try hard, I can get through to even the most difficult or unmotivated students* (RAND Item 2) (Berman et al., 1977), deepened curiosity in the construct. Over the years, there has been expansion as well as refinement of the construct, with researchers conducting studies measuring teacher self-efficacy and its relationship to teaching and learning. This paper does not provide a review of the measures used to evaluate teacher self-efficacy. (For a thorough treatment of such measures and their evolution, reference Tschannen-Moran and Woolfolk Hoy, 2001).

The construct, while born out of the Rotter tradition of Locus of Control, has evolved into a construct aligned with Bandura's Social Cognitive Theory. Bandura identified teacher efficacy as a type of self-efficacy – a cognitive process in which people construct beliefs about their ability to perform at a given level of attainment or the conviction that one can successfully execute behavior required to produce outcomes (Bandura, 1986, 1997; Tschannen-Moran et al., 1998; Hoy, Tarter, & Woolfolk Hoy, 2006). Additionally, Bandura (1986) noted that the outcomes people anticipate depend largely on their judgment of how well they will be able to perform in given situations. As teacher self-efficacy theory evolved and a deeper understanding of the construct developed, so too did its practical definition and application. One of the first definitions declared teacher efficacy as “the extent to which a teacher believes he or she has the capacity to affect student performance” (Berman et al., 1977, p. 137). A teacher's belief or conviction that they can influence how well students learn, even those who may be difficult or unmotivated, was the definition utilized by researchers Guskey and Passaro (1994) and Gibson and Dembo (1984).

Ashton and Webb (1986) defined teacher's sense of efficacy as “their belief in their ability to have a positive effect on learning” (p.142). A more contemporary explanation of teacher self-efficacy comes from the work of Tschannen-Moran et al. (1998) and defines teacher self-efficacy as the “teacher's belief in his or her capability to organize and execute the courses of action required to successfully accomplish a specific teaching task in a particular context” (p. 233). It is this definition that will be used as the basis for the remainder of this discussion in this study.



Ultimately, a teacher makes a judgment about his or her self-efficacy based on two considerations: the teaching task and the context of the task (Tschannen-Moran et al., 1998). Teachers do not feel equally efficacious in every aspect of what they do in the classroom (Bandura, 1997; Wheatley, 2002). As a construct, teacher self-efficacy is context specific (Bandura, 1997; Tschannen-Moran et al., 1998), meaning that in different situations a teacher may have differing levels of self-efficacy beliefs. A chemistry teacher who feels particularly efficacious when lecturing to sedentary students may not feel as efficacious when he has to instruct students in a lab setting. Additionally, teachers may have varying levels of efficacy from one class block to another or from one grade level to another (Ross et al., 1992).

The assessment of the teaching task requirements include student factors, such as the student's perceived ability, motivation, home-life and socioeconomic status; and contextual factors such as school leadership, collegial support, and the availability of resources (Tschannen-Moran & Woolfolk Hoy, 2007).

As the teacher is making the judgment about self-efficacy through the assessment of the task and its context, he or she is also making an appraisal as to the strengths and weaknesses possessed in relation to the task. The teacher judges his or her personal capabilities, such as skill, knowledge, and personality traits, and balances them against personal weaknesses or liabilities in the particular teaching context (Tschannen-Moran et al., 1998). The chemistry teacher referenced earlier would be thinking to himself, "I am very good at supervising my students when they are focused and seated for a lecture, but, when they begin to move around and become active in the lab setting, I do not have the proficiency to manage them."

Teachers make judgments of their self-efficacy based on the verbal encouragement of important others, the success or failure of others who serve as role models, perceptions of past experiences of teaching, and the level of emotional arousal experienced as they anticipate and practice teaching (Tschannen-Moran & McMaster, 2009). These sources of efficacy are vital to the formation of teacher self-efficacy beliefs.

However, all of this information is dependent upon the teacher's cognitive processing. Tschannen-Moran et al. (1998) noted that "cognitive processing determines how the sources of efficacy information will be weighed and how they will influence the analysis of the teaching task and the assessment of personal teaching competence" (p. 230). The teacher cannot make the efficacy judgment without thinking specifically about the dimensions of the task, the situation in which he finds himself, and what he brings to the table for the completion of the task. Efficacy judgments are made when these constituent parts interact (Tschannen-Moran et al., 1998).

Depending on the level of self-efficacy achieved other factors will emerge that influence behavior, such as resilience, persistence, goal setting, and effort. Greater efficacy will lead to greater effort and more persistence, which in turn will lead to a better performance in the classroom (Tschannen-Moran et al., 1998). This then creates a new mastery experience for the teacher that will be used to shape future efficacy beliefs. The opposite could be said if there is a decrease in efficacy: it will lead to less effort and persistence, resulting in poor teaching outcomes that will in turn also help shape future experiences (Tschannen-Moran et al., 1998).

Because the process of self-efficacy development is cyclical, there are opportunities for a teacher to develop new beliefs based on experiences that reshape their teaching. However, it is important to note that this is true only to a point. With experience, teachers develop a relatively stable sense of their teaching competence that is combined with their analysis of a new task to produce judgments about expected efficacy of that task (Ross, 1998; Tschannen-Moran et al., 1998; Tschannen-Moran & Woolfolk Hoy, 2007). Beliefs about teaching are likely to remain as is unless there are some intervening experiences that cause the teacher to reassess his or her beliefs (Bandura, 1997).

Teacher self-efficacy is considered a self-referent construct in that it relies on the teacher to estimate his or her own level of efficacy. “It is important to note that self-efficacy is a motivational construct based on self-perception of competence, rather than actual level of competence” (Tschannen-Moran & Woolfolk Hoy, 2001, p.946). This means that teachers may over- or underestimate their level of efficacy in relation to an external assessment of teaching. A teacher might report a high level of self-efficacy but her students routinely demonstrate low achievement, or a teacher’s students routinely show high achievement outcomes, yet he self-reports very low self-efficacy beliefs.

Because of the desire to positively impact students is central to most teacher’s motivation to teach, doubts about one’s teaching efficacy will often be the most potent type of doubt required to foster true change in teaching practice (Wheatley, 2002). Wheatley (2002) claimed that “teachers who have doubt about their teaching efficacy often have important benefits to learning and educational reform” (p. 5). Wheatley proposed that having doubt can be beneficial because reflecting on one’s abilities and

self-efficacy can lead to new insights and understandings (Tschannen-Moran & Johnson, 2011).

### **Teacher Self-Efficacy and Student Outcomes**

Student outcomes, the ultimate aim of any educational program, school or classroom, can be diverse depending on the context. Currently, student achievement is an outcome that is ever-present as schools prepare students to meet federal, state, and local mandates and to compete in global markets of the future. Research has linked teacher self-efficacy to student progress. “Teacher efficacy is increasingly recognized as a pivotal variable influencing teacher practice and student outcomes” (Ross, 1994, p. 381).

Teachers’ sense of efficacy has been shown to be a construct related to student outcomes such as achievement, (Armor, et al., 1976, Ashton & Webb, 1986; Moore & Esselman, 1992; Ross, 1992), motivation (Midgley, et al., 1989), and sense of efficacy (Anderson et al., 1988). Higher teacher efficacy is associated with higher student cognitive achievement (Ross, 1996). Table 2 outlines some of the past research that demonstrates a relationship between teacher self-efficacy and student achievement.

Table 2

*Teacher self-efficacy and student achievement research studies*

| <b>Teachers who have higher self-efficacy beliefs:</b>                                |   |
|---|---|
| produced higher student outcomes in areas such as math and English.                   | Anderson, Green, and Loewen, 1988<br>Moore and Essleman, 1994<br>Ross, 1992; Ross and Cousins, 1993 |
| had students who outscored their peers on Iowa Test of Basic Skills.                  | Moore and Essleman, 1992  |
| in rural and urban schools saw greater achievement in their students.                 | Watson, 1991  |
| were associated with higher student cognitive achievement.                            | Ross, 1996  |
| are better able to produce higher student achievement than teachers with lower levels | Evans, 2011   |

While there is no direct link between teacher efficacy and student achievement, there is a causal pattern that does support the rationale that teachers who hold high self-efficacy beliefs exhibit specific behaviors in the classroom that can lead to an increase in student achievement. "The relationship between teacher efficacy and student achievement is likely because of differences in teacher behavior" (Tucker, Porter, Reinke, Herman, Avery, Mack, & Jackson., 2005 p. 30). Gibson and Dembo (1984) found important behavioral differences between teachers with high and low efficacy, differences that may yield variation in student achievement.

McLaughlin and March (1978) found a causal chain linking teacher self-efficacy to student achievement through the efficacy and behaviors of students. Ashton and Webb (1986) also explain a process that links teachers' sense of efficacy from teacher behaviors to students' sense of efficacy, behavior, and achievement. The integrated model of teacher self-efficacy presented by Tschannen-Moran, Woolfolk Hoy, and Hoy

(1998) also illustrates this association through a pathway that connects teachers' self-efficacy to the consequences of teacher behaviors and performances of teachers.

Because this plausible link exists, there is a deeper need to study the construct of teacher self-efficacy and its relationship to student achievement. While there are some empirical studies that exist, there is not enough information for educators to be content and express a notion that the construct has reached saturation levels and can no longer provide valuable information.

**Seminal works.** In the mid to late 1970s, two studies reported positive correlations between the degree of teacher efficacy and the amount of gain students made on standardized tests of reading (Allinder, 1994). One of those investigations involved the Los Angeles Unified School District, which was implementing a new reading program. The district wished to identify school and classroom policies that were most successful in raising the reading scores of inner-city students and utilized the services of the Rand Corporation. Using a sample of 20 elementary schools in the district, the authors administered questionnaires to 6<sup>th</sup> grade teachers, principals, reading specialists. The achievement measure utilized was the 6<sup>th</sup> grade Comprehensive Test of Basic Skills (CTSB) (Armor et al., 1976).

One aspect of teachers' individual attitudes toward teaching in minority schools was studied by the researchers - their sense of efficacy in dealing with minority students (Armor et al., 1976). They utilized the two Rand items, combining the responses to these questions into one global measure of efficacy (Armor et al., 1976). Their findings were clear and significant:

The more efficacious the teacher felt, the more their students advanced in reading achievement. This measure was strongly and significantly related to increases in reading. Obviously, teachers' sense of efficacy is only one part of the morale and commitment to teaching that we presume is a major influence on learning. Our finding that efficacy effects achievement demonstrates the importance of these predisposition factors for effective teaching (Armor et al., 1976, pg. 23).

In a much larger scale study, conducted again by the Rand Corporation for the United States Office of Education, Berman et al. (1977) in Volume VII of the change agent series report, present an analysis of the survey data collected in 100 Title III projects covering 20 states. Their research presented more than 20 dependent variables and was designed as a continuation of previous research.

With respect to teacher self-efficacy, the major findings of the report showed that "the more efficacious teachers were and the higher their verbal ability, the greater the improvement in student performance" (Berman et al., 1977, p. 145). The study of teacher efficacy beliefs indicated that the extent to which teachers believed they are capable of influencing student performance affected their enthusiasm and persistence in working with their students and ultimately their students' achievement (Berman et al., 1977).

While this was a massive study that dealt with multiple dependent variables, its biggest contribution was that it shed light on the probable powerful implications teacher efficacy can have on student achievement, and the behavior of teachers with high efficacy beliefs to be willing to implement innovative projects.

**Secondary Level Teachers and Achievement.** Ashton and Webb (1986) conducted a multiphase study observing school organizations and teacher behaviors as

they relate to student achievement. The portion of this study that is of relevance to this paper is the Systemic Observation Study of the basic skills classes in the high school. A sample of 48 basic skills teachers was used from four secondary schools in the jurisdiction, with the basic skills classes consisting of mathematic and language instruction for students who had failed previous achievement measures (Ashton & Webb, 1986).

The achievement measures used were the mathematics, language, and reading subtests of Metropolitan Achievement Test (MAT). To assess teacher attitudes, Ashton and Webb utilized a teacher questionnaire that included the two Rand efficacy questions, an eight-item forced choice answer of efficacy (Webb efficacy measure), 15 vignettes (Webb efficacy vignettes), two items about stress (one about teaching the basic skills class and one about teaching in general), and a question about the responsibility they felt for student learning (Ashton & Webb, 1986). Additionally, the classroom observation measures employed were “the Climate and Control System to measure classroom climate; the Teacher Practices Observation Record to gather information about teacher instructional styles; and the Engagement Rate Form to measure students’ attentiveness.” Ashton and Webb’s (1986) findings

strongly support the hypothesis that teachers’ sense of efficacy is related to student achievement. Furthermore, the results support the assumption that teachers’ efficacy beliefs are situation-specific. Students’ math achievement was significantly related to teacher beliefs in the efficacy of teaching and student’s language achievement was significantly related to teacher’s sense of personal efficacy (p. 138).



“Efficacy beliefs are not one-dimensional and, consequently, can be expected to have different relationships to different subject matter, depending on the teachers’ beliefs about subject being taught and the students in the class” (Ashton & Webb, 1986, p. 139). Thus teacher’s beliefs about the efficacy of mathematics teaching may be the most salient efficacy belief in determining students’ achievement behavior in mathematics (Ashton & Webb, 1986). Because of the small sample size and unique characteristics of basic skills classes, the conclusions that can be drawn from the study were limited and tentative (Ashton & Webb, 1986). They were however, supportive of the conclusions drawn from earlier phases of the study (for a complete overview of all portions of the study, reference Ashton & Webb, 1986). Teachers with a strong sense of efficacy tended to have a classroom climate that was warm and supportive of student needs, and students scored higher on achievement tests than did students of teachers with a lower sense of efficacy (Ashton & Webb, 1986).

Although the correlation nature of the study precludes any direct inferences regarding the effect of teacher sense of efficacy on student achievement...the strength of our findings warrant the design of experimental research to examine the impact of teachers’ sense of efficacy on student achievement (p. 144).

*Achievement and Grade Transitions.* Using the work of Gibson and Dembo (1984) and Ashton and Webb (1986), Anderson, Greene and Loewen (1998) built their study around the premise that “it has been demonstrated there are relationships between teachers sense of efficacy and student achievement, but that these relationships may be subject and /or context specific” (p. 150). This study examined relationships between and among teachers sense of efficacy, thinking skills and student achievement.

The measure used to assess teacher self-efficacy in the Anderson et al. (1998) study was the 16-items scale from Gibson and Dembo (1984) and student achievement was measured by the Canadian Achievement Tests Levels 12, 13 and 16 (Anderson et al., 1988). The Teacher Sense of Efficacy Scale was mailed to 77 third and sixth grade teachers in three school jurisdictions in South Alberta Canada; of these 64 were completed and 24 were chosen for further study (12 high efficacy and 12 low efficacy). This was a yearlong study that measured student achievement in the fall and the spring of the school year.

The results demonstrated that for grade three students, teachers' personal sense of efficacy at the beginning of the year appears to be a significant factor in student achievement. The same could not be said of grade six teachers. The teachers in the study reasoned that at the sixth grade level, teachers influence over student learning begin to diminish (Anderson et al., 1988). This poses interesting questions when looking at teacher efficacy and student achievement at the various levels of schooling, specifically at the transition from middle school to high school.

**Social Studies Teacher Self-Efficacy and Achievement.** In his investigation, Ross (1992) considered the relationship between student achievement, teacher efficacy, and interactions with assigned coaches. The sample consisted of 18 grade seven and grade eight history teachers from 36 classrooms who were implementing a specific innovation with help from six coaches. Using Gibson and Dembo's (1984) measure for teacher efficacy and a knowledge instrument consisting of multiple choice items selected from the Ontario Assessment Instrument Pool, Ross (1992) indicated that student achievement was higher in classrooms with teachers who made more contact with

coaches and in classrooms with teachers who had greater confidence in the effectiveness of education. “A second hypothesis of this study, that student achievement would be higher in classrooms with higher teacher’s efficacy beliefs, was also confirmed” (p. 60).

### **Teacher Self-Efficacy and Teacher Behaviors**

The construct of teacher self-efficacy has been linked to the behaviors teachers’ exhibit in the classroom (Allinder, 1995; Ashton & Webb, 1986; Gibson & Dembo, 1984; Ross, 1992; Smylie, 1990; Tschannen-Moran & Hoy, 2001). Ross (1994) ... “Teacher efficacy is increasingly recognized as a pivotal variable influencing teacher practice and student outcomes” (p. 381). Teacher self-efficacy has been researched primarily as it relates to teachers’ behavior (Smylie, 1990), and it indicates that teachers with a high sense of personal efficacy engage in behaviors that are different from those with low personal efficacy (Allinder, 1994).

Teachers with strong self-efficacy beliefs tend to exhibit stronger motivational factors and behaviors that are related to the amount of effort they put into teaching, the goals they set, their persistence when things do not go smoothly, and their resilience in the face of setbacks (Bandura, 1997; Tschannen-Moran & Woolfolk Hoy, 2001).

**Effort.** How much effort a teacher puts into the craft of teaching differs based on the level of self-efficacy beliefs held. A proportional relationship exists between teacher self-efficacy and effort. As a teacher’s sense of efficacy increases, so too does their level of motivation and effort. Teachers with a higher sense of efficacy seem to employ a pattern of strategies that minimize negative effects on students, and provide a definition of the classroom that is characterized by academic work (Ashton & Webb, 1986). They tend to exhibit more zeal and enthusiasm for teaching (Allinder, 1994), are less likely to

use seat-work to control students (Ashton & Webb, 1986), and exhibit high levels of planning and organization (Allinder, 1994). A propensity to be innovative and try new instructional methods to specifically meet the needs of their learners is also characteristic of teachers who have a high sense of personal efficacy (Allinder, 1994; Berman et al., 1977; Guskey, 1981; Stein & Wang, 1988).

In studying the efficacy beliefs of science teachers, Enochs, Scharmann, and Riggs (1995) found that teachers whose sense of efficacy was high were more likely to engage in activity-based learning. Ashton and Webb (1986) found that highly efficacious teachers demonstrated “withitness”, meaning they seldom overlooked infractions and took actions to curb inappropriate student behavior. Additionally, they also expressed an insight that these teachers tended to be attentive to the individual needs of all students in their classes. Teachers with strong efficacy beliefs exhibited behaviors that included sustaining on-task behavior in students resulting in classes that were focused strongly on academics and learning (Allinder, 1994; Podell & Soodak, 1993).

**Goals.** Setting and attaining goals is imperative to the task of teaching. Teachers with a higher sense of efficacy promote an expectation of achievement (Ashton & Webb, 1986). Behaviors of highly efficacious teachers include maintaining high academic standards and communicating clear expectations to students, as well as setting more challenging goals (Allinder, 1994). These teachers also have a positive affect in shaping students’ attitudes toward school and to their teacher, as well as the material they learn (Rose & Medway, 1981). Those teachers that possess high personal efficacy beliefs hold high expectations for students, exhibit positive interpersonal relationships, and demonstrate effective instructional strategies (Tschannen-Moran & Barr, 2004). Teachers

reporting a low sense of efficacy indicated a preference for custodial care more often than teachers with an average or high sense of efficacy (Denham & Michael, 1981) and tended to stratify students in groups based solely on ability level or rely on extrinsic rewards and negative sanctions to motivate students.

**Persistence.** When things do not go as planned in the classroom or a student struggles to learn from a well-planned lesson, teachers with a high sense of personal efficacy exhibit behaviors that are indicative of determination, doggedness, and diligence. They are not likely to give up when struggles arise. They are apt to persisting longer during a lesson with students who are struggling (Allinder, 1994; Gibson & Dembo, 1984), and less likely to be critical of student mistakes (Ashton, & Webb, 1986; Gibson & Dembo, 1984); while teachers with low sense of efficacy easily give up on students who do not learn quickly and criticize students for their failure (Gibson & Dembo, 1984). If students do present challenges in the classroom, teachers with high self-efficacy beliefs are less likely to refer students to special education (Meijer & Foster, 1998), and are not as likely as those with a lower sense of efficacy to feel threatened by the misbehavior of their students (Ashton & Webb, 1986).

**Resilience.** Teachers who have higher self-efficacy beliefs are more resilient in the face of set-backs or negative experiences. Greater efficacy is related to more positive attitudes in teaching (Guskey, 1988). Highly efficacious teachers are not as likely to leave the profession prematurely (Fives, Hamman, & Oleverx, 2007), and their higher self-efficacy levels are linked to a greater commitment to teaching, resulting in people who remain in teaching for duration of their careers (Coldarci, 1992; Guskey, 1984).

Glickman and Tamashiro (1982) found that teachers who left the profession were found to have lower teacher efficacy beliefs than teachers in either their first or their fifth years.

### **Mathematics Content Knowledge and Pedagogical Knowledge**

“Increasing expectations about what students should know and be able to do, breakthroughs in research on how students learn, and the increasing diversity of the student population have put significant pressure on the knowledge and skills teachers must have in order to meet the educational goals of the 21<sup>st</sup> century” (Capraro, Capraro, Parker, Kulm, & Raulerson, 2005, p. 102). Teaching mathematics effectively is a complex task in which teachers must have a profound understanding of math (Ma, 1999), as well as the knowledge and skills to know which instructional strategy best ensures understanding of the mathematical concept. “The teacher need not only understand that something is so, the teacher must further understand why it is so” (Shulman, 1986, p. 9) and then be able to communicate both to students. This is the essence of mathematics content knowledge and mathematics pedagogical knowledge.

Most American teachers have a conception of mathematics as a static body of knowledge, involving a set of rules and procedures that are applied to yield one right answer (Stipek, Givvin, Salmon, & MacGyvers, 2001). Knowing mathematics means being skillful and efficient in performing procedures and manipulating symbols without necessary understanding what they represent (Thompson, 1992). Instruction that is currently being provided in mathematics, particularly at the middle school level, is very uniform and is not oriented toward understanding of material nor does it provide intellectually challenging opportunities for students (TIMSS, 2007). U.S. teachers tend to use tasks that engage students with low-level cognitive activity, such as memorizing

and recalling, rather than high-level thinking, such as reasoning and problem solving (TIMSS, 2007). All in all, teachers need to be disseminators of the understandings of mathematical concepts, rather than just purveyors of procedural problem solving.

**Mathematics Content Knowledge.** Content knowledge is the knowledge a teacher has of the subject-specific concepts and is generally acquired through the formal educational process (Cancoy, 2010). Mathematics content knowledge is the combination of knowledge, skills, and understanding of the mathematical concepts held by the teacher (Evans, 2011). In order to implement the standards and the curriculum effectively, school leaders and systems rely upon the work of skilled teachers who understand the subject matter (Ball, Hill, Bass, 2005).

The expectation that teachers have a major in the content area they wish to teach, or at least have numerous credit hours of study in that area, has dramatically changed the landscape of teaching – teachers are now considered to be content experts. While today's teachers have a plethora of resources available to them to assist with content knowledge, such as textbooks and internet sites, no amount of information can replace a true understanding of the content. Shulman (1986). "The teacher need not only understand that something is so; the teacher must further understand why it is so, on what grounds its warrant can be asserted, and under what circumstances our beliefs in its justification can be weakened and even denied" (p.9). Content knowledge involves the teacher being able to go beyond the simple rudimentary functions of the content; for example, solving an algebraic equation. The teacher must be able to explain to the student the conceptual implications needed to solve an algebraic equation.

Teachers with higher levels of content knowledge, more positive attitudes toward mathematics, and higher self-efficacy are better able to produce higher student achievement than teachers with lower levels (Evans, 2011). Schwackerhamer, Koellner, Basile, and Kimbrough (2009) found that teacher's self-efficacy was higher for those teachers who had taken four or more math content courses. Teachers who lack procedural and content knowledge have lower self-efficacy (Bates, Matham & Kim, 2011).

However, mathematics content knowledge is a difficult construct to measure. Researchers have often characterized teacher content knowledge by using "proxy" measures, such as reviews of college courses taken (Phelps & Schillings, *in press*). A Task Group Report of the National Math Advisory Panel (2008) identifies three ways in which the content knowledge of a teacher can be measured: 1) teacher certification; 2) mathematics course work, and tests of teachers' mathematics knowledge. Teacher certifications have different requirements from state to state. In Virginia, individuals seeking licensure must have: 1) passed the Virginia Communications and Literacy (VCLA) with a score of at least 235 in the areas of Reading and Writing or have a cumulative score of at least 470; 2) passed the Praxis II, a content assessment; and 3) completed the course requirements for their content area (Virginia Department of Education, 2011).

A teacher who wishes to teach Algebra I in Virginia must also pass the Praxis II specialty area test in the area of Mathematics with a score of 178 or higher (VDOE, 2011). The Praxis II Mathematics assessment is a norm referenced specialty area assessment that measures subject specific content knowledge in mathematics (Educational Testing Service, 2011). The Praxis II also offers a criterion referenced



portion that could be used to assist teachers in determine areas of strength and weakness. This information can then be used to develop professional development in the content area.

Additionally, in the state of Virginia, teachers must take specific mathematics courses in order to receive a license to teach Algebra I. These requirements are outlined in Table 3.

Table 3

*Course Requirements for Mathematics Endorsement in Virginia*

| Math 6-12 endorsement  | Algebra Add-On   |
|--|--|
| Graduated from an approved teacher prep program in mathematics | Graduated from an approved teacher prep program in Algebra I   |
| OR   | OR   |
| Completed a major in mathematics                               | Hold a baccalaureate degree from a regionally accredited university AND an endorsement in a teaching area AND completed 24 hours of coursework that include the following areas: |
| OR   | Elementary functions   |
| 36 semester hours of course work in the following areas:       | Trigonometry   |
| Algebra  | Linear Algebra   |
| Geometry   | Euclidean Geometry   |
| Analytic Geometry  | Probability and Statistics   |
| Probability and Statistics                                     | Discrete Math  |
| Discrete Math  | Computer science   |
| Computer Science   | Calculus   |
| Calculus   |  |

There are currently not many tools that can assess a person's content knowledge; therefore, the measures listed above often used to determine a teacher's mathematics content knowledge. In order to implement the standards and the curriculum effectively, school leaders and systems rely upon the work of skilled teachers who understand the subject matter (Ball et al., 2005).

**Mathematics Pedagogical Knowledge.** Knowledge alone cannot make a distinguished teacher (Lin & Tsai, 1999). In order to respond appropriately, teachers not only need to understand the concepts, they need to know how these concepts can be best explained to students (Krauss, Brunner, Kunter, Baumert, Blum, Jordan, & Neubrand, 2008). The National Commission on Teaching and America's Future (1996) stated that in order to teach mathematics effectively, one must combine a profound understanding of mathematics with knowledge of students as learners, and to skillfully pick from and use a variety of pedagogical strategies. Ma (1999) further defines profound as deep, connecting math with greater conceptual power; vast, connecting topics with similar conceptual power; and thorough, the capacity to weave all parts of the subject into a coherent model.

Pedagogical knowledge goes beyond the knowledge of the subject matter and includes the ways of presenting and formulating the subject matter to make it more comprehensive to the student (Shulman, 1986). Since the process of learning is influenced by the teacher, it is important to understand how teachers explain concept "A" to students, what they emphasize and what they do not; what ways they choose to help students understand (Even, 1993).

There is a robust relationship that exists between teacher self-efficacy and pedagogical knowledge, and this relationship influences student achievement (Swars, et al., 2007). The more courses teachers take with respect to mathematics methods, the higher their self-efficacy (Swars et al., 2007; Utley et al., 2005). Hill, Rowan, and Ball (2005) found in a longitudinal study that a teacher's mathematical content and pedagogical knowledge was significantly related to student achievement gains in both the first and third grades.

Given that self-efficacy beliefs manifest into the actions of the teacher, it is likely the behaviors of the teacher in the classroom, with respect to pedagogy, provide the link between self-efficacy and mathematics pedagogy. The time spent studying mathematics pedagogy, either as a pre-service, novice, or experienced teacher, leads to a higher self-efficacy, and teachers' with a higher level of self-efficacy have a propensity to be innovative and try new instructional methods that specifically meet the needs of his or her students (Allinder, 1994; Berman et al., 1977, Guskey, 1981; Stein and Wang, 1988). Tschannen-Moran and Barr (2004) found that highly efficacious teachers demonstrate the effective use of instructional strategies.

One way to measure pedagogical knowledge is by the number of methods courses. Teachers take several methods courses in college to prepare them for the classroom. The grades earned in those courses can also be reviewed to provide additional information. Once teachers become practicing teachers, they undergo professional development to further enhance the level of pedagogical knowledge they possess. Additionally, teachers acquire new knowledge through various mastery and vicarious experiences that teaching presents, such as learning various ways of explaining concepts to students by having students ask questions or by seeing other teacher's model practices for them. Mathematics pedagogical knowledge can also be measured by a series of questions on a survey that target the specific pedagogical skills such as using graphing calculators, Algebra vocabulary or the use of manipulatives with students.

Regardless of how content knowledge or pedagogical knowledge are measured, a teacher's understanding of mathematics concepts and how to best share those understandings immensely impacts student learning.

## Summary

Implications from empirical research involving student achievement and teacher self-efficacy demonstrate that a relationship exists between the two variables. Teachers who maintain higher self-efficacy beliefs are shown to exhibit behaviors in the classroom that lead to greater student outcomes. “The enduring confidence that many scholars, reformers, and teacher educators have had in teacher efficacy is due to the fact that teacher efficacy has been consistently and positively associated with factors of interest, such as student achievement” (Wheatley, 2002, p. 6). Empirical evidence from research studies by Armor et al., (1976), Ashton and Webb (1986) Berman et al. (1977), Anderson et al. (1988), and Ross (1992) demonstrates that the relationship between teacher self-efficacy and student achievement is significant, proportional, and positive. This is encouraging information for anyone in the field of education as it provides a possible insight into how to garner greater student outcomes.

However, what is missing from this research base are contemporary examples of the impact teacher self-efficacy can have on student achievement. There is little research that is current and links efficacy to standards of learning assessments currently being given in the state of Virginia (Tschannen-Moran & Barr, 2004). Virginia, using the Standards of Learning (SOL) tests, mandates that students be tested in a variety of subject areas to ascertain minimal competency levels based on prescribed curriculum standards. From a combination of these tests and other measures, schools are judged. There is considerable interest and need to develop research studies that investigate the relationship between teacher self-efficacy and student scores on SOL tests.

Bandura (1997) argued that the task of creating learning environments conducive to the development of cognitive competencies rests heavily on the talents and self-efficacy of teachers. Evidence indicates that teachers' beliefs in their instructional efficacy partly determines how they structure academic activities in their classrooms. Ashton and Webb (1986) provided evidence illustrating a difference in the achievement of students in math that was correlated to teacher efficacy beliefs. Anderson et al. (1988) provided information that spoke to the difference self-efficacy beliefs of teachers played in the achievement of students in the third grade versus the sixth grade. These are important and relevant findings that warrant further probing.

The implications for mathematics instruction, a particularly daunting subject for some to learn and for some to teach, are high, as well as plausible. Using teacher self-efficacy and student achievement data, the potential exists to unlock answers that could be of great value and benefit. It would also prove fruitful to perform teacher efficacy and achievement research at various transition points in schooling – such as the 8<sup>th</sup> and 9<sup>th</sup> grade. Are there differences in efficacy beliefs and achievement attainments that are significant in these two levels? Could these two ideas be combined and investigations conducted regarding the relationship between the two variables for a subject such as Algebra I, which is currently taught at both the middle school and high school levels?

While one can argue that there is a rich line of research implicating the powerful effects of teacher self-efficacy, it does not warrant complacency. The construct itself may be more than thirty years old and the level of empirical research done to cement the relationship between teacher self-efficacy and student achievement present; however, there are more relationships to explore. This means looking more deeply at the behaviors

and beliefs our teachers manifest and hold in the classroom to guide them toward more positive student outcomes. A foundation has been laid and an opportunity for growth exists.

## **CHAPTER 3: METHODOLOGY**

### **Overview and Purpose**

The primary purpose of this study was to explore the relationship between teacher self-efficacy beliefs and the level of achievement their students obtained as evidenced by the Algebra I Virginia Standards of Learning (SOL) assessment. This study also explored teachers' math content knowledge, mathematics pedagogical knowledge and the relationship of each of these to their self-efficacy beliefs as teachers and to student achievement, as measured by the Algebra I End-of-Course SOL test. Finally, this study explored whether there were significant differences between teachers who teach Algebra I at the middle school level and versus those who teach Algebra I at the high school level in each of the three variables under study.

### **Research Questions**

This investigation proposed the following research questions in a sample of middle school and high school teachers of Algebra I in several school districts in Virginia.

1. To what extent are teacher self-efficacy beliefs for mathematics instruction related to student achievement in Algebra I?
  - a. Do teacher self-efficacy beliefs differ significantly between teachers who teach Algebra I to students in middle and high school?
  - b. To what extent are there differences in the relationship between teacher self-efficacy beliefs and student achievement based on whether teachers teach Algebra I to students in middle or high schools?

2. To what extent are Algebra I teachers' self-efficacy beliefs for mathematics instruction related to mathematics content knowledge (as assessed by certification type)?
  - a. Do Algebra I teachers' mathematics content knowledge differ significantly based on teaching students in middle or high schools?
  - b. To what extent is Algebra I teachers' mathematics content knowledge correlated to student achievement in Algebra I?
3. To what extent are Algebra I teachers' self-efficacy beliefs related to their level of mathematics pedagogical knowledge?
  - a. Does teacher mathematics pedagogical knowledge differ significantly based on teaching Algebra I to students in the middle school versus the high school?
  - b. To what extent is Algebra I teachers' mathematics pedagogical knowledge correlated to student achievement in Algebra I?

### **Research Design**

This quantitative study sought to determine the relationship between teacher sense of self-efficacy and student achievement. Extant data from measures of teacher self-efficacy, mathematics content knowledge, and mathematics pedagogical knowledge was analyzed using various descriptive and analytic statistics. Achievement data will be comprised of average scaled scores from the 2010 or 2011 End-of-Course (EOC) Algebra I Standards of Learning (SOL) assessment given in Virginia. Data will be collected using EXCEL and analyzed using the predictive analytics software program Statistical Package



for the Social Sciences (SPSS). Table 7 in this chapter outlines the data sources and analytic strategies for each research question.

### **Participants**

The participants for this study came from a convenience sample of mathematics teachers who were members of The College of William and Mary Tidewater Team for Math Education grant program during the 2010 or 2011 school year. The College of William and Mary's Tidewater Team invited 30 school divisions from across the state to participate in the grant program, which provided mathematics teachers with professional development on mathematics instruction. All thirty school divisions sent one or more mathematics teachers from grades 6-12 to participate in the program, for an overall total of 104 participants. These 104 participating teachers taught a variety of mathematics classes at the middle and high school level, but not all teachers who participated in the Tidewater Team program taught Algebra I.

From this pool of 104 participants in the Tidewater Team, this study extracted a convenience sample of 48 participants, representing 15 different public school divisions from across the state of Virginia. Each of these 48 teachers taught Algebra I and had students who completed the EOC Algebra I SOL in the spring of 2010 or 2011. Each participant completed the Teacher Self-Efficacy Scale for Mathematics Instruction (TSESMI) survey online via Survey Monkey.

Of the 48 participants, 41.7% percent were teaching Algebra I in middle schools, and 58.3% were teaching Algebra I at the high school level. Teachers who completed the survey held a variety of certifications for teaching in the state of Virginia. The majority of the teachers (n=28) who participated in the study held the Math 6-12 endorsement

(58%), while six percent of participants held an elementary plus certification (n=3), ten percent held an Algebra Add-On certification (n=5), and 25% held a Math 6-12 Plus certification (n=12). None of the 48 participants in this study held an Elementary endorsement; however, there were teachers in the original pool of 104 participants who held this endorsement. A summary of these endorsements can be found on Table 4.

Table 4

*Summary of Teaching Certifications*

| Certification   | Details   |
|-----------------|---|
| Elementary      | Teachers with an elementary endorsement only  |
| Elementary Plus | Teachers with an elementary endorsement as their primary endorsement plus an additional endorsement (i.e. middle school math, middle 4-8) |
| Algebra Add-on  | Teachers who have a non-math related teaching endorsement with the Algebra I Add-on certification (i.e. French, special education)        |
| Math 6 -12      | Teachers with the Math 6-12 endorsement only  |
| Math 6-12 Plus  | Teachers with the Math 6-12 endorsement plus an additional endorsement (i.e. computer science, physics)                                   |

The majority (73%) of the teachers who participated in the study were white (n=35), while 13% were African American (n=6), six percent were Hispanic (n=3) and eight percent did not specify their ethnicity (n=4). The cohort group of teachers who participated in the study had a wide variety of teaching experience, from novice to experienced. Years of teaching experience for the study participants ranged from one to 35 years, with a mean of 12 years. For the middle school level, years of teaching experience ranged from two to 35 years, with a mean of 14 years. At the high school level, teacher experience spanned from one to 30 years of teaching experience, with a mean of 10 years.

**Procedures**

As a part of The College of William and Mary's Tidewater Team for Math Education grant program, all 104 participants were notified they would be part of a study and consented to their participation during the 2009-2010 or 2010-2011 school year. Each participant completed the TSESMI in June of 2010 or June of 2011 and was aware that their EOC Algebra I average scaled scores would be a part of the grant program study. Additionally, participating school divisions were contacted and provided permission for average scaled EOC Algebra I SOL scores to be provided to the research team in the spring of 2010 or 2011. The school divisions provided the SOL scores, not the teachers.

To ensure that the participants of this study were protected from unethical treatment or testing, this study had two layers of human subject's protection. Layer one consisted of the original study, conducted during the 2009-2010 or 2010-2011 school year, and the TSESMI survey being approved by The College of William and Mary's Protection for Human Subjects Committee (PHSC) prior to any of the teachers participating in the grant program. This approval was granted and received by Dr. Marguerite Mason at the College of William and Mary. The second layer consisted of approval being sought and granted by the PHSC in November of 2013 for the use of the extant data from the original Tidewater Team grant program for the explicit purposes of this study.

**Data Sources**

The study utilized a measure of teacher self-efficacy, the Teacher Sense of Self-Efficacy Scale for Mathematics Instruction (TSESMI) and additional survey questions

were used to determine the level of pedagogical and content knowledge of each teacher. The survey consisted of a total of 36 questions and 15 free response questions which requested demographic data and teaching and professional development histories. Additionally, scaled scores from the Virginia EOC Algebra I SOL assessment in the spring of 2010 or 2011 were received from the school divisions for those teachers who participated in the study. Table 5 outlines the questions on the survey, as well as identifies how these questions were used in this study.

Table 5

*TSESMI Survey Response Scales and Study Measures*

| <b>TSESMI Question(s)</b> | <b>Response Mechanism</b>   | <b>Study Measure</b>  |
|---------------------------|---|---|
| 1-19                      | <ul style="list-style-type: none"> <li>• Nine-point scale</li> <li>• Choices range from 1(not at all), 3 (very little), 5 (some degree), 7 (quite a bit) and 9 (a great deal)</li> <li>• Even choices reflect a level of belief between the expressed levels assigned to the odd numbers</li> </ul> | <ul style="list-style-type: none"> <li>• Used as a measure of Teacher Self-Efficacy</li> <li>• Mean of responses used to determine overall self-efficacy score for each teacher</li> </ul>  |
| 20-24                     | <ul style="list-style-type: none"> <li>• Five-point scale</li> <li>• Choices are Excellent (E), Above Average (AA), Average (A), Below Average (BA) to No Knowledge (NK)</li> </ul>   | <ul style="list-style-type: none"> <li>• Used as a measure of Mathematics Pedagogical Knowledge</li> <li>• Mean of response used to determine the overall mathematics pedagogical knowledge for each teacher</li> </ul>   |
| 25-36                     | <ul style="list-style-type: none"> <li>• Five-point scale</li> <li>• Choices are Strongly Disagree (SD), Disagree (D), uncertain (U), Agree (A) and Strongly Agree (SA)</li> </ul>  | <ul style="list-style-type: none"> <li>• Not applicable; therefore not used in this study</li> </ul>  |
| 37- 40                    | <ul style="list-style-type: none"> <li>• Free response questions requiring participants to enter their answers by hand</li> </ul>   | <ul style="list-style-type: none"> <li>• Not applicable; therefore not used in this study</li> </ul>  |
| 41 – 51                   | <ul style="list-style-type: none"> <li>• Demographic questions</li> <li>• Some questions require the participants to select from a pre-set list, while others allow the participant to enter his or her own response</li> </ul>   | <ul style="list-style-type: none"> <li>• Question 47 – used as a measure for Mathematics Content Knowledge</li> <li>• Questions 41, 42, 43, 44, 45, 46 and 51 used for demographic information about participants</li> <li>• Questions 48, 49 and 50 were not used in this study as they were not applicable</li> </ul> |

**Teacher Sense of Self-Efficacy for Mathematics Instruction Survey.** In order to capture the teacher's self-efficacy beliefs about teaching, Tschannen-Moran and Woolfolk Hoy's (2001) Teacher Sense of Self-Efficacy Scale short form (TSES), was adapted to focus on the participant's perceptions on mathematics instruction. The TSES was a self-report measure that is a frequently used instrument to gather self-efficacy data from teachers. The adaptations to the TSES were made by the original Tidewater Team for Mathematics Instruction and the resulting measure was named the Teacher Sense of Efficacy for Mathematics Instruction (TSESMI). It is the extant data from the administration of this TSESMI survey that was used for the purposes of this study.

The TSESMI survey consisted of a total of 36 questions and 15 free response questions which requested demographic data and teaching and professional development histories. The first 19 questions on the TSESMI related to a teachers self-efficacy beliefs about teaching mathematics, and were addressed by questions with stems such as "How much can you do..." or "To what extent..." The mean of these first 19 questions will be used to determine each teacher's self-efficacy score for this study.

The self-efficacy questions (1-19) allowed the participant to choose the level of his or her personal belief to the various question prompts from a 9-point Likert scale. Participants selected from responses such as one "Not At All", three "Very Little," five "Some Degree," seven "Quite A Bit," or nine "A Great Deal." Even numbered choices were also presented and reflected a level of belief between the expressed levels assigned to the odd numbers presented above. The overall self-efficacy score for each teacher will be calculated as the mean of questions 1-19 from the TSESMI. A copy of the TSESMI, in its entirety, can be found in Appendix B.

**Teacher Mathematics Content Knowledge.** Three ways in which content knowledge has been measured include: teacher certification, mathematics course work, and tests of teachers' mathematics knowledge (National Mathematics Advisory Panel, 2008, Chapter 5, p. 6). For the purposes of this study, only teacher certification was used as a measure of a teacher's mathematics content knowledge. Because this study relied on extant data, this was the only information available from the Tidewater Team to assess a teacher's mathematics content knowledge. Question 47 on the TSESMI survey asked participants to select their certification or endorsement from the following choices (select all that apply): Math 6-12, Algebra Add-on, Elementary K-8, Special Education, and/or Provisional, or the participants could type in any "Other" certifications or endorsements in the space provide on the survey.

**Teacher Mathematics Pedagogical Knowledge.** Mathematics pedagogical knowledge can be measured by the number of methods courses and professional development courses taken by a teacher, from tests of teachers' pedagogical knowledge or from information specific to various instructional strategies used in the mathematics classroom (National Board of Professional Teaching Standards, 2011). In this study, five questions (20-24) from the TSESMI survey were used to assess the mathematics pedagogical knowledge of each teacher. Table 6 outlines the five questions from the TSESMI survey used to assess a teacher's mathematics pedagogical knowledge.

Table 6

*Mathematics Pedagogical Knowledge Questions from TSESMI Survey*

| Number | Question  |
|--------|---|
| 20     | How would you rate your knowledge of the use of manipulatives such as Algebra tiles in the Algebra classroom? |
| 21     | How would you rate your knowledge of the use of graphing calculators in the Algebra classroom?                |
| 22     | How would you rate your capacity to explain Algebra vocabulary?   |
| 23     | How would you rate your ability to make use of a variety of grouping practices in the Algebra classroom?      |
| 24     | How would you rate your use of strategies to differentiate varying levels of student knowledge and/or need?   |

The mathematics pedagogical knowledge questions (20-24) from the TSESMI survey asked each participant to rate their level of knowledge of the information in each question and allowed each participant to choose from five responses: Excellent (E), Above Average (AA), Average (A), Below Average (BA) and No Knowledge (NK). The overall mathematics pedagogical knowledge score for each teacher was calculated as the mean of questions 20-24 from the TSESMI. A copy of the TSESMI, in its entirety, can be found in Appendix B.

**Student Achievement.** In the state of Virginia, all students enrolled in a public school take state mandated assessments, called Standards of Learning (SOL) tests, to assess whether students have met the specific minimum expectations for learning (Virginia Department of Education, 2012). This study focused on only one of the many tests that are written and administered by the Virginia Department of Education (VDOE) each year – the End of Course (EOC) Algebra I SOL, 2001 standards. This test is given to students once they complete the full Algebra I course at their school, whether at the



middle school or high school level. For some students this testing period may be in January of the current school year, while, for others, it might be in the spring of the current school year. For this study, all of the students who took Algebra I during the 2009-2010 or 2010-2011 school year, took the EOC Algebra I SOL in the spring of 2010 or 2011.

The test consists of 50 multiple choice questions that measure content knowledge, mathematical processes, reasoning and critical thinking (VDOE, 2012), as well as 10 multiple choice field test questions that are not a part of the student's overall score, but used to test questions that may be used on future SOL assessments.

Student performance is graded on a scale of 0-600 with 400 representing the minimum level of acceptable proficiency (pass/proficient) and 500 representing advanced proficiency (pass/advanced). A score between 0-399 represents the fail/below basic level. This score, 0-600, referred to as the Average Scaled Score, is the score that is reported to the school division, school, teacher, student, and parent.

Average scaled scores are derived from cut scores, which represent the number of correct answers required for the achievement levels of pass proficient or pass advanced on a particular SOL test. These cut scores, which are adopted by the Virginia Board of Education (VBOE), are based on the original form of the test called the "standard setting form." This form is reviewed by a committee of educators, known as the standards setting committee, who reviews the test form and makes recommendations to the VBOE as to the number of correct answers, or raw score, that should be required for the various achievement levels (fail/below basic, pass/proficient, pass/advanced). For the EOC Algebra I (2001 standards) SOL test referenced in this study, the cut scores for

pass/proficient (a scaled score of 400 to 499) was 27 out of 50 questions answered correctly. To earn a scaled score of pass/advanced (500-600), a student must have answered at least 45 of 50 questions correctly. Members of the Tidewater Team from the College of William and Mary secured the average scaled scores for each participant who taught Algebra I and whose student's completed the EOC Algebra I SOL from the participating school division in the spring of 2010 or 2011. More information about this process can be found in the Data Collection section of this study.

One additional note of importance regarding the EOC Algebra I SOL: in 2012 the Virginia Department of Education made changes to the Algebra I standards and the assessment. The test became more rigorous and contained test items that required complex, higher level thinking skills on the part of the student. The assessment also included Technology Enhanced Items (TEI) which required the students to manipulate various items while answering the question online. The test was no longer completely multiple choice, but contained free response and other types of question formats. This is an important note to those reading this study, as this study was conducted using the 2001 Algebra I standards with student testing occurring in 2010 and 2011, prior to the new SOL test being given to students.

**Demographic Data.** The demographic questions utilized from the TSESMI survey were a mixture of pre-set answer selections and free-response questions. The pre-set demographic questions utilized in this study asked for the participant's gender (male or female), racial identify (African American, Hispanic, Other or White-Non-Hispanic), and level of teaching (middle or high school). The free-response questions utilized in this study asked the participant the number of years they have been teaching, the school and

school division in which they currently teach, and the participant's name. A copy of the TSESMI, in its entirety, can be found in Appendix B.

### **Data Collection**

The TSESMI survey was administered online to all 104 participants in the Tidewater Team for Math Education grant program via Survey Monkey in June of 2010 or 2011. Data were collected on-site from participants at the conclusion of their grant program and were secured by the grant project director. Student achievement data were gathered from each participating school division in the form of averaged scaled scores for each teacher in EXCEL. Only one score was reported for each teacher. Student names were never shared to ensure confidentiality. To protect the confidentiality of the teachers, only one researcher of the Tidewater Team grant program staff was privy to the data that connected the teacher's self-efficacy belief score to student achievement results.

For the purposes of this study, all data utilized were extant data and several collection processes were utilized to ensure that the rights of the human subjects were protected and that confidentiality was maintained. The TSESMI survey data from 2010 and 2011 was sent to the researcher from the Tidewater Team via EXCEL. This EXCEL file contained the participant's responses to all 36 scale questions and all 15 free-response questions on the survey questions, as well as each participant's name, school, division and when they completed the survey. This information was then synthesized by the researcher into a form that could be imported into SPSS. Synthesized information that was utilized in this study included the responses to questions 1-19 (a measure of teacher self-efficacy), questions 20-24 (a measure of mathematics pedagogical knowledge),

question 47 (a measure of mathematics content knowledge), and demographic questions 41 through 46 and 51.

Due to a data storage issue, the average scaled score SOL data for each of the original 104 Tidewater Team participants was no longer available for this study; however, this information could be obtained from each school divisions. In order to obtain this information, a letter and email was sent to both the math coordinator and the division director of testing for all 30 school divisions that originally participated in the Tidewater Team grant program in 2010 or 2011. A copy of this letter can be found in Appendix C. This letter explained the purpose of the request for information and outlined a secure process for sending the achievement data. Accompanying this letter was an enclosure that provided the name of each teacher and the year in which they participated in the Tidewater Team grant program. A sample of this enclosure can be found in Appendix D.

Of the 30 school divisions invited to provide information, 15 responded, with achievement data for a total of 48 teachers. This pool of 48 teachers became the convenience sample for this study. The school divisions sent this achievement data to a third party who then combined this new information with the information collected from the TSESMI survey. A random number was assigned to each teacher, the teacher's names were removed and this information was forwarded back to the researcher. This final EXCEL spreadsheet did not contain any identifying information that could tie the self-efficacy score or the achievement score back to any one teacher or school division. This data was then used in SPSS to conduct the statistical analyses outlined in the next section.

## Data Analysis

The synthesized extant data were imported into SPSS for analysis. This study relied primarily on SPSS to determine specific descriptive and analytic data, such as means, bivariate correlations and independent sample *t*-tests. The reliability of the measure for teacher self-efficacy (TSESMI questions 1-19) and mathematics pedagogical knowledge (TSESMI questions 20-24) was determined by calculating the Cronbach's alpha coefficient of internal consistency.

To answer research questions in number One, *"To what extent are teacher self-efficacy beliefs for mathematics instruction related to student achievement in Algebra I?"*, TSESMI survey questions 1-19 and average scaled EOC Algebra I SOL scores were used to run a bivariate correlation provide information as to the extent of the relationship between the teacher's self-efficacy and the achievement of his or her students in Algebra I. To answer research questions in number One A, *"Do teacher self-efficacy beliefs differ significantly between teachers who teach Algebra I to students in middle and high schools?"*, an independent samples *t*-test was conducted using TSESMI survey questions 1-19, and 43, to determine if there was a significant difference between the self-efficacy beliefs of teachers at the middle school and the high school level. To answer question One B, *"To what extent are there differences in the relationship between teacher self-efficacy beliefs and student achievement based on whether a teacher teaches Algebra I to students in middle or high schools?"*, separate bivariate correlations were conducted using TSESMI survey questions 1-19 and 43 and the average scaled EOC Algebra I SOL scores to determine if a relationship existed between middle or high school Algebra I teachers' self-efficacy beliefs and student achievement.

To answer research question number Two, *“To what extent are Algebra I teachers’ self-efficacy beliefs for mathematics instruction related to mathematics content knowledge (as assessed by certification type)?”*, a bivariate correlation was conducted using TSESMI survey questions 1-19 and 47 to determine if a relationship existed between the teacher’s self-efficacy beliefs to his or her mathematics content knowledge. To gather information to answer question Two A, *“Do Algebra I teachers’ mathematics content knowledge differ significantly based on teaching students in middle or high school?”*, an independent samples *t*-test was conducted using TSESMI survey questions 43 and 47 to determine if there was a significant difference between the mathematics content knowledge of teachers at the middle school versus high school level. Question Two B, *“To what extent is Algebra I teachers’ mathematics content knowledge correlated to student achievement in Algebra I?”*, was answered by performing a bivariate correlation using TSESMI survey question 47 and the average scaled EOC Algebra I SOL scores, thus determining if a relationship existed between the Algebra I teachers’ mathematics content knowledge and student achievement.

To answer research question number Three, *“To what extent are Algebra I teachers’ self-efficacy beliefs related to their level of mathematics pedagogical knowledge?”*, a bivariate correlation was conducted using TSESMI survey questions 1-19 and 20-24 to provide a correlation of the teacher’s self-efficacy beliefs and mathematics pedagogical knowledge. Question number Three B, *“Does a teacher’s mathematics pedagogical knowledge differ significantly based on teaching Algebra I students in the middle or high school?”*, was answered using an independent samples *t*-test with TSESMI survey questions 20-24 and 43. This process provided information to

assess whether or not there was significant difference between the mathematics pedagogical knowledge of middle school versus high school teachers. To answer question Three B, “*To what extent is Algebra I teachers’ mathematics pedagogical knowledge correlated to student achievement in Algebra I?*”, a bivariate correlation was conducted using TSESMI survey questions 20-24 and the average scaled Algebra I SOL score to determine if there is relationship between the Algebra I teachers’ mathematics pedagogical knowledge and student achievement. A summary of the various data analyses used in this study is shown in Table 7.

Table 7

*Data Sources and Data Analysis*

| Research Question   | Data Source  | Analysis                           |
|---|--|------------------------------------|
| 1. To what extent are teacher self-efficacy beliefs for mathematics instruction related to student achievement in Algebra I?  | TSESMI survey questions 1-19<br>Average scaled EOC Alg I SOL scores        | Bivariate Correlation              |
| a. Do teacher self-efficacy beliefs differ significantly between teachers who teach Algebra I to students in middle and high schools?   | TSESMI survey questions 1-19 and 43  | Independent samples <i>t</i> -test |
| b. To what extent are there differences in the relationship between teacher self-efficacy beliefs and student achievement based on whether a teacher teaches Algebra I to students in middle or high schools? | TSESMI survey questions 1-19 and 43<br>Average scaled EOC Alg I SOL scores | Separate bivariate correlations    |
| 2. To what extent are Algebra I teachers' self-efficacy beliefs for mathematics instruction related to mathematics content knowledge (as assessed by certification type)?                                     | TSESMI survey questions 1-19 and 47  | Bivariate Correlation              |
| a. Do Algebra I teachers' mathematics content knowledge differ significantly based on teaching students in middle or high school?   | TSESMI survey questions 43 and 47  | Independent samples <i>t</i> -test |
| b. To what extent is Algebra I teachers' mathematics content knowledge correlated to student achievement in Algebra I?  | TSESMI survey question 47<br>Average scaled EOC Alg I SOL scores           | Bivariate Correlation              |
| 3. To what extent are Algebra I teachers' self-efficacy beliefs related to their level of mathematics pedagogical knowledge?  | TSESMI survey questions 1 – 19 and 20-24                                   | Bivariate Correlation              |
| a. Does a teacher's mathematics pedagogical knowledge differ significantly based on teaching Algebra I students in the middle or high school?   | Survey items 20-24 and 43  | Independent samples <i>t</i> -test |
| b. To what extent is Algebra I teachers' mathematics pedagogical knowledge correlated to student achievement in Algebra I?  | Survey items 20-24<br>Average scaled EOC Alg I SOL scores                  | Bivariate Correlation              |

TSESMI, *Teacher Sense of Efficacy Scale for Mathematics Instruction*EOC Alg I SOL, *End of Course Standards of Learning assessment, Algebra 1*



### **Limitations of the Study**

Research methods must be considered, and in this case, the study had a moderate sample size. This is a relatively small sample size ( $n = 48$ ), with 20 teachers at the middle school level and 28 at the high school level. A general rule of thumb is to choose as large a sample as possible in order to compare outcomes with the overall population, While the sample size was good for overall correlations; it was small for when the overall sample was divided into middle and high school levels, where approximately 30 participants is recommended to be able to relate variables (Creswell, 2005). Additionally, when calculating correlation coefficient using limited sample sizes, the results may indicate no significant relationships (Stangor, 2004). Increasing the size of the sample is likely to increase the statistical power between the variables under study (Stangor, 2004).

Additionally, this is a convenience sample comprised of teachers who opted to participate in a year-long professional development program. Only 15 of the 133 (11.3%) school divisions in the state were represented in the sample. Because all of the teachers who participated were from public schools in Virginia, the findings may not be generalizable outside of Virginia or outside of the public school realm.

The focus of this study was the relationship between the constructs of teacher self-efficacy, mathematics content knowledge, mathematics pedagogical knowledge, and student achievement; no assumptions can be made of a causal nature with respect of one construct to another based on the findings

As a construct, teacher self-efficacy is a self-referent measure. Teachers are reporting what they perceive themselves capable of, not what they are actually doing. Given this, it is possible for teachers to over- or under-estimate their self-efficacy beliefs.

This is the first study conducted with the TSESMI, which is adapted from the TSES. Additional testing needs to be conducted with the measure to establish validity and reliability of the instrument. As the survey was taken at the end of the school year, “school fatigue” may have caused some participants to not be as attentive as needed on the survey.

The TSESMI survey was given to participants as a self-paced exercise. The instructions for each section of the survey were read by the teachers as he or she moved through each portion of the online survey. This may or may not have impacted the understanding of various terms used in some of the questions such as “manipulatives,” “assessment strategies,” “capacity,” or “algebraic proofs.” While these are common educational terms, there is no way to be sure that all participants held a common understanding of the terms.

The measure for student achievement in this study was the End-of-Course Algebra I assessment developed by the Virginia Department of Education for the purposes of assessing student knowledge of state standards of learning in Algebra I. This was the only measure for student achievement use; therefore, there was only one point of correlation with other variables. Adding an additional measure of student achievement may improve the study. Examples of such measures are the National Assessment of Education Progress (NAEP), the Trends in Math and Science Study (TIMSS), Programme for International Assessment (PISA), Stanford assessments, or other state assessments

For the purposes of this study, the survey that was given to teachers participating in the Tidewater Team for Math Education professional development program asked

teachers to indicate their current level of teaching certification in the state of Virginia. The certifications represented in this study ranged from the Elementary Plus endorsement to Mathematics 6-12 plus endorsement. This certification level was then used as a measure of the teacher's mathematics content knowledge. As with the measure for student achievement, the classification of a teacher's content knowledge is based on one point of data. Using certification levels as a proxy measure of content knowledge is not uncommon as it is a straightforward and simply method of gathering information that can provide some level of even comparison amongst participants. The findings from this study could be enhanced by adding additional measures of content knowledge.

Mathematics pedagogical knowledge was measured in this survey by a series of questions that asked about the teachers their knowledge of items such as math manipulatives, the use of graphing calculators, math vocabulary usage, and differentiation strategies. All of these are various pedagogical methods that can be used in the mathematics classroom. Mathematics pedagogical knowledge can be measured by the number of methods courses and professional development courses taken by a teacher, from tests of teachers' pedagogical knowledge or from information specific to various instructional strategies used in the mathematics classroom (National Board of Professional Teaching Standards, 2011). Adding additional measurement dimensions to the TSESMI survey may enhance the study's findings.

### **Ethical Considerations**

The Tidewater Team for Math Education Grant program Director, Dr. Margie Mason received permission to conduct the original data collection and study through the College of William and Mary's Human Subjects Committee. I also sought and obtained

approval through the College of William and Mary's Human Subjects Committee. The nature of this current study was very sensitive in that a link was established between specific teachers and their respective student achievement data from the spring of 2010 or 2011. To ensure the confidentiality of both students and teachers, I considered how to connect self-efficacy data to specific student achievement data without any identifying information regarding the teacher; a third party was utilized and was privy to data that directly connected a specific teacher to the teacher specific achievement data. Once the data points were connected, random numbers were assigned and any reference to the teacher, his or her school, or the teacher's school division was removed. This synthesized data set was what was used by the researcher of this study to conduct the statistical analyses outlined. At no time will the teacher's name, school or school division be referenced.

### **Summary**

This study explored whether a relationship existed between the self-efficacy beliefs of Algebra I teachers in the state of Virginia and the level of achievement of their students, as measured by the EOC Algebra I assessment given in 2010 or 2011. It also sought to determine if there was a relationship between the self-efficacy beliefs and the teachers' mathematics content knowledge and mathematics pedagogical knowledge. The final piece to this study was to determine what relationships existed between these four variables, teacher self-efficacy, student achievement, mathematics content knowledge and mathematics pedagogical knowledge, and the level at which the teacher teaches Algebra I, either middle or high school. The results of the data analyses can be found in Chapter Four.

## **CHAPTER 4: RESULTS**

### **Introduction**

The primary purpose of this study was to explore the relationship between teacher self-efficacy beliefs and the level of achievement their students obtained as evidenced by the Algebra I Virginia Standards of Learning (SOL) assessment. This study also explored the teachers' mathematics content knowledge and mathematics pedagogical knowledge and the relationship of each of these to the teacher's self-efficacy beliefs and to student achievement, as measured by the Algebra I End of Course (EOC) SOL assessment. Finally, this study also sought to explore whether there was a significant difference between teachers who teach Algebra I at the middle school level versus those who teach Algebra I at the high school level in each of the three variables under study. This chapter provides an overview of the results of this study and is organized by research question.

### **Demographic Data for Teacher Participants**

A total of 48 teachers from The College of William and Mary's Tidewater Team for Math Education grant program participated in the study. All participants were current teachers from public schools within the Commonwealth of Virginia and all teachers had students who took the Algebra I SOL EOC assessment in the spring of 2010 or 2011. The demographic data collected through the Teacher Self-Efficacy Scale for Mathematics Instruction (TSESMI) survey were analyzed to show various participant demographics, a summary of which can be found on Table 8.

Table 8

*Demographic Details of Study Participants*

| Demographic                       | Middle School | High School | Total | Percent |
|-----------------------------------|---------------|-------------|-------|---------|
| Level                             |               |             |       |         |
| Middle                            | 20            | —           | 20    | 41.7    |
| High                              | —             | 28          | 28    | 58.3    |
| Gender                            |               |             |       |         |
| Male                              | 8             | 11          | 19    | 39.6    |
| Female                            | 12            | 17          | 29    | 60.4    |
| Certification                     |               |             |       |         |
| Elementary plus                   | 0             | 3           | 3     | 6       |
| Algebra Add-on                    | 1             | 4           | 5     | 10      |
| Math 6-12                         | 11            | 17          | 28    | 58      |
| Math 6-12 plus                    | 8             | 4           | 12    | 25      |
| Racial Identity                   |               |             |       |         |
| African American                  | 2             | 4           | 6     | 13      |
| Hispanic                          | 2             | 1           | 3     | 6       |
| Not Specified                     | 0             | 4           | 4     | 8       |
| White, Non-Hispanic               | 16            | 19          | 35    | 73      |
| Mean Years of Teaching Experience | 14            | 10          | 12*   | —       |

\*Overall mean for years of teaching for all participants

Of the 48 participants, 41.7% percent were teaching Algebra I in middle schools, and 58.3% were teaching Algebra I at the high school level. Teachers who completed the survey held a variety of certifications for teaching in the state of Virginia. The majority of the teachers ( $n=28$ ) who participated in the study held the Math 6-12 endorsement (58%), while six percent of participants held an elementary plus certification ( $n=3$ ), ten percent held an Algebra Add-On certification ( $n=5$ ), and 25% held a Math 6-12 Plus certification ( $n=12$ ).

The majority of the teachers ( $n=35$ ) who participated in the study were white (73%), while 13% were African American ( $n=6$ ), six percent were Hispanic ( $n=3$ ) and eight percent did not specify their ethnicity ( $n=4$ ). The cohort group of teachers who participated in the study had a wide variety of teaching experience, from novice to experienced. Years of teaching experience for the study participants ranged from one to 35 years, with a mean of 12 years. For the middle school level, years of teaching experience ranged from two to 35 years, with a mean of 14 years. At the high school level, teacher experience spanned from one to 30 years of teaching experience, with a mean of 10 years.

### **Exploratory Factor Analysis**

To determine the construct validity of questions 1-19 on the TSESMI, an Exploratory Factor Analysis (EFA) was conducted using the Statistical Package for the Social Sciences (SPSS), a predictive analytics software program. EFA can be used to investigate a theoretical construct, such as Teacher Self-Efficacy, which might be represented by a set of items, in this case questions 1-19 from the TSESMI survey. The scree plot demonstrated that eigenvalues leveled off after one factor, thus one factor was specified. In the analysis calling for one factor, it was determined for this one factor, teacher self-efficacy, the factors extracted would only be comprised of questions with a factor load greater than .50. However, Questions #1, 2 and 7 were .175, .279 and .384, respectively. Thus, Question #1, Question #2 and Question #7 were removed from the mean calculation for Teacher Self-Efficacy.

Using maximum likelihood extraction, the EFA produced an eigenvalue of 8.84 that accounted for 55.3% of the total variance. The factor loadings ranged from .66 to .92.

This indicated that the 16 questions on the TSESMI were loading on the same factor, teacher self-efficacy, and were, therefore, measuring the same thing. It should be noted that this level of confidence for this EFA was moderate as there were only 48 participants available for use with the 16 questions to determine the mean for the teacher's self-efficacy. Standards indicate that there should be at least 10 participants for each question used in the factor analysis (MacCullum, Widaman, Zhang & Hong, 1999). Factor analysis assesses whether the questions on the assessment measure the same construct, in this case teacher self-efficacy beliefs, and thus are a measure of construct validity.

The three questions removed, questions #1, 2 and 7, present the teacher with factors they may not have much control over, thus impacting their overall sense of teacher self-efficacy. Question #1 reads "To what extent are students appropriately placed into Algebra?" and question #2 reads "To what extent are students adequately prepared for Algebra?"

At the beginning of each new school year or semester, teachers do not have control over which students are placed into their Algebra I class. That decision is most likely made by a collaborative effort between the Guidance Counselor, the previous math teacher, the student, and the student's parent based on overall grades and SOL scores. Based on the school division's sequence for mathematics and pre-requisites, a teacher in Algebra I could receive students who received an "A" or a "D" in the previous math course, or students who must repeat the course due to failure. The Algebra I teacher is then expected to move all of these students through the curriculum, regardless of previous grades, SOL scores, prior knowledge or skill level.



Question #7 reads “To what extent do you use a variety of assessment strategies in Algebra?” In this era of high stakes accountability, many teachers are mandated to give common assessments and division benchmark assessments. These assessments are typically modeled after the EOC SOL, which, in 2010 and 2011, consisted of all multiple choice questions. Because this level of consistency is required, many teachers may have felt they did not have control over the types of assessment strategies they could use, as they needed to always be preparing students for multiple choice mathematics assessments.

### **Descriptive Statistics**

Self-efficacy for mathematic instruction scores for teachers ranged from 3.94 to 8.88, and had a mean of  $M=6.70$  ( $SD=1.00$ ). The mean of the self-efficacy scores for middle school teachers was  $M=6.36$  ( $SD=1.05$ ) and  $M=6.95$  ( $SD=.916$ ) for high school teachers. In order to determine that there was internal consistency between the items used to measure the self-efficacy of each participant, a Cronbach’s Alpha was run from TSESMI questions 3-6 and 8 -19 using SPSS. For this data set, Cronbach’s Alpha was .940. A Cronbach’s Alpha score of .7 or higher confirms there is reliability among the questions. For Alpha scores greater than .900, it is noted that there may be some redundancy in the questions and the researcher may be able to shorten the assessment (Tavakol and Dennick, 2011).

Mathematics pedagogical knowledge scores ranged from 2.80 to 5.00, with an  $M=3.71$  ( $SD=.519$ ). The mean for middle school teachers’ mathematics pedagogical knowledge was  $M=3.52$  ( $SD=.542$ ), while at the high school level the mean for teacher’s mathematics pedagogical knowledge was  $M=3.85$  ( $SD=.463$ ). In order to determine that

there was internal consistency between the items used to measure the mathematics pedagogical knowledge of each participant, a Cronbach's Alpha was determined from TSESMI questions 20-24 using SPSS. For this data set, Cronbach's Alpha was .650, which would provide evidence that there is poor internal consistency between the questions used to assess the mathematics pedagogical knowledge of the teachers. A Cronbach's Alpha score of .7 or higher confirms there is reliability among the questions and the questions on the assessment measure the same construct, in this case mathematics pedagogical knowledge. "A low Alpha value could be due to a low number of questions" (Tavakol & Dennick, 2011). In this study, five questions were used to assess the construct of mathematics pedagogical knowledge.

Overall, the average scaled scores on the Algebra I SOL ranged from 405 (pass proficient) to 559 (pass advanced), with  $M=474$  (pass proficient) ( $SD=38.3$ ). At the middle school level, the average scaled score for teachers ranged from 434 (pass proficient) to 533 (pass advanced) and  $M=499$  (pass proficient) ( $SD=28.5$ ). At the high school level, the average scaled scores ranged from 405 (pass proficient) to 559 (pass advanced), with  $M=455$  (pass proficient) ( $SD=33.7$ ). Table 9 outlines the descriptive statistics.

*Table 9**Descriptive Statistics*

|                                   | Range       | Mean | Standard<br>Deviation |
|-----------------------------------|-------------|------|-----------------------|
| Teacher Self-Efficacy             | 3.94 – 8.88 | 6.70 | 1.00                  |
| Middle School                     | 3.94 – 8.00 | 6.36 | 1.05                  |
| High School                       | 4.53 – 8.88 | 6.95 | .916                  |
| Mathematics Pedagogical Knowledge | 2.80 – 5.00 | 3.71 | .519                  |
| Middle School                     | 2.80 – 4.50 | 3.52 | .542                  |
| High School                       | 3.00 – 5.00 | 3.85 | .463                  |
| Student Achievement               | 405 – 559   | 474  | 38.3                  |
| Middle School                     | 434 – 533   | 499  | 28.5                  |
| High School                       | 405 – 559   | 455  | 33.7                  |

**Correlations**

To determine if there was a relationship between a teacher's self-efficacy beliefs, mathematics content knowledge, mathematics pedagogical knowledge and the achievement of his or her students, bivariate correlations were conducted using SPSS.

Table 10 outlines these data. In the sections that follow, more details and information is discussed with respect to each research question.

*Table 10**Pearson's Correlations for all Study Participants*

|                       | Content<br>Knowledge | Pedagogical<br>Knowledge | Student<br>Achievement |
|-----------------------|----------------------|--------------------------|------------------------|
| Teacher Self-Efficacy | -.228                | .412**                   | .026                   |
| Content Knowledge     | -                    | -.308*                   | .196                   |
| Pedagogical Knowledge | -                    | -                        | -.112                  |

\*\*  $p < .01$ , \* $p < .05$

Additionally, to determine if there was a relationship between a teacher's self-efficacy beliefs, mathematics content knowledge, mathematics pedagogical knowledge, student

achievement, and the level at which the teacher instructs, separate bivariate correlations were also conducted, separating the data into the middle school level versus high school level with high school scores above the diagonal and middle school scores below the diagonal. Table 11 outlines this data. In the sections that follow, more details and information is discussed with respect to each research question.

*Table 11*

*Pearson's Correlations by Middle or High School Level*

|                       | Teacher<br>Self-<br>Efficacy | Content<br>Knowledge | Pedagogical<br>Knowledge | Student<br>Achievement |
|-----------------------|------------------------------|----------------------|--------------------------|------------------------|
| Teacher Self-Efficacy | -                            | -.262                | .522**                   | .175                   |
| Content Knowledge     | .064                         | -                    | -.355                    | .041                   |
| Pedagogical Knowledge | .174                         | -.001                | -                        | -.111                  |
| Student Achievement   | .354                         | -.143                | .393                     | -                      |

*Note.* Middle school correlations can be found below the diagonal; and High school correlations are above the diagonal, \*\*  $p < .01$

### **Research Question One**

*To what extent are teacher self-efficacy beliefs for mathematics instruction related to student achievement in Algebra I?*

To determine if there was a relationship between a teacher's self-efficacy beliefs and the achievement, as measured by the EOC Algebra I SOL, an independent bivariate correlation was completed using SPSS. The data in Table 11 reveals a lack of a linear relationship between the variables ( $r = .026$ , n.s.). There is a non-significant relationship between a teacher's self-efficacy beliefs and student achievement; meaning that a teacher's self-efficacy beliefs were not found to be related to the student's achievement in this study.

**Question 1A:** *Do teacher self-efficacy beliefs differ significantly between teachers who teach Algebra I to students at the middle school and the high school level?*

To examine the difference between the self-efficacy beliefs of teachers at the middle school level versus the high school level, an independent samples *t*-test was conducted using SPSS. The mean score for the self-efficacy beliefs of middle school teachers  $M=6.36$  ( $SD=1.05$ ), and the mean score for the self-efficacy beliefs of high school teachers was  $M=6.95$  ( $SD=.916$ ). A statistical difference was shown between the two means  $t(46) = 2.04, p < .05$ , indicating that teachers at the high school level have higher self-efficacy beliefs than do teachers at the middle school level. Table 12 outlines this data.

Table 12

*Group Statistics for Middle School versus High School Self-Efficacy Beliefs*

| Level                       | N  | Mean | Standard deviation |
|-----------------------------|----|------|--------------------|
| Middle school self-efficacy | 20 | 6.36 | 1.05               |
| High school self-efficacy   | 28 | 6.95 | .916               |

**Auxiliary finding.** This series of research questions essentially addresses two variables, teacher self-efficacy beliefs and student achievement. The analysis up to this point does not include information about the difference between the student achievement scores for teachers at the middle school versus the high school level. Given that all of the other variables have been references with respect to the difference at the middle school versus the high school levels, having this additional information about student achievement scores at these two levels is important to ensure a complete perspective on the differences between high school and middle school teachers with respect to each of the study variables.

To examine the difference between the achievement scores of teachers at the middle school level versus the high school level, an independent samples *t*-test was conducted using SPSS. The mean score for the achievement scores of middle school teachers  $M=499$  ( $SD=28.5$ ), and the mean score for the achievement scores of high school teachers was  $M=455$  ( $SD=33.7$ ). A statistical difference was shown between the two means  $t(46) = 4.78$ ,  $p<.05$ , indicating that teachers at the middle school level have higher achievement scores than do teachers at the high school level. Table 13 outlines this data.

Table 13

*Group Statistics for Middle School versus High School Student Achievement*

| Level                             | N  | Mean | Standard Deviation |
|-----------------------------------|----|------|--------------------|
| Middle School Student Achievement | 20 | 499  | 28.5               |
| High School Student Achievement   | 28 | 455  | 33.7               |

**Question 1B:** *To what extent are there differences in the relationship between teacher self-efficacy beliefs and student achievement based on whether the teacher teaches Algebra I to students in middle or high school?*

Separate bivariate correlations were conducted using SPSS to determine the extent of the difference between middle and high school teachers with respect to their self-efficacy beliefs, as measured by questions on the TSESMI survey, and student achievement, as measured by the EOC Algebra I SOL. The data in Table 12 reveals there is no relationship between the variables at the middle school level ( $r = .354$ , n.s.). These data do not demonstrate a statistically significant relationship between a teacher's self-efficacy beliefs and student achievement at the middle school level; meaning that a

teacher's self-efficacy beliefs are not related to the student's achievement at the middle school level. The data in Table 12 also reveal there is no relationship between the variables at the high school level ( $r = .175$ , n.s.). These data do not demonstrate a statistically significant relationship between a teacher's self-efficacy beliefs and student achievement at the high school level; meaning that a teacher's self-efficacy beliefs were not related to the student's achievement at the high school level for the participants in this study.

### **Research Question Two**

*To what extent are Algebra I teachers' self-efficacy beliefs for mathematics instruction related to mathematics content knowledge, as assessed by certification type?*

Mathematical content knowledge can be measured in a variety of ways. Chapter 3 provides an overview of the various methods that can be used to assess a teacher's content knowledge. For the purposes of this study, mathematical content knowledge was self-reported by each participant in the TSESMI survey. Participants identified their primary, secondary and/or tertiary certifications for teaching in the state of Virginia. These certifications were then coded for entry into SPSS. Table 14 shows illustrates how the certifications were coded in SPSS.

Table 14

*Teaching Certification Explanation and Coding for SPSS*

| Code in SPSS | Level           | Details   |
|--------------|-----------------|---|
| 1            | Elementary      | Teachers with an elementary endorsement only  |
| 2            | Elementary Plus | Teachers with an elementary endorsement as their primary endorsement plus an additional endorsement (i.e. middle school math, middle 4-8) |
| 3            | Algebra Add-on  | Teachers who have a non-math related teaching endorsement with the Algebra I Add-on certification (i.e. French, special education)        |
| 4            | Math 6-12       | Teachers with the Math 6-12 endorsement only  |
| 5            | Math 6-12 Plus  | Teachers with the Math 6-12 endorsement plus an additional endorsement (i.e. computer science, physics)                                   |

To determine if there was a relationship between a teacher's self-efficacy beliefs and mathematics content knowledge, as measured by the certification level reported on the TSESMI survey, an independent bivariate correlation was completed using SPSS. The data in Table 11 reveal there is non-significant relationship between the variables ( $r = -.228$ , n.s.); meaning that a teacher's self-efficacy beliefs were not related to the mathematics content knowledge for the participants in this study.

Table 11 outlines the data for this finding.

**Question 2A:** *Do Algebra I teachers' mathematics content knowledge differ significantly based on teaching students in the middle or high school*

To examine the difference between the mathematics content knowledge of teachers at the middle school level versus the high school level, an independent samples *t*-test was conducted using SPSS. Mathematics content knowledge was measured by the level of certification each teacher reported. Table 4 references these various certification



levels. The mean score for the mathematics content knowledge of middle school teachers  $M=3.52$  ( $SD=.542$ ) and the mean score for the mathematics content knowledge of high school teachers was  $M=3.85$  ( $SD=.463$ ). A statistical difference was shown between the two means  $t(46) = 2.60$ ,  $p<.05$ , indicating that teachers at the high school level had higher mathematics content knowledge, as measured by certification level, than did the teachers at the middle school level. Table 15 summarizes these data.

Table 15

*Group Statistics for Middle School versus High School Mathematics Content Knowledge*

| Level                           | N  | Mean | Standard Deviation |
|---------------------------------|----|------|--------------------|
| Middle School Content Knowledge | 20 | 3.52 | .542               |
| High School Content Knowledge   | 28 | 3.85 | .463               |

**Question 2B:** *To what extent is Algebra I teachers' mathematics content knowledge correlated to student achievement in Algebra I?*

To examine the extent of the relationship between a teacher's mathematics content knowledge, as measured by certification level, and student achievement as measured by the EOC Algebra I SOL, an independent bivariate correlation was completed using SPSS. The data in Table 11 reveals there is not a relationship between a teacher's content knowledge and student achievement variables ( $r = .196$ , n.s.); meaning that a teacher's mathematics content knowledge was not related to student's achievement for the participants in this study.

**Auxiliary finding.** Question 2B specifically inquires about the extent of the relationship between a teacher's mathematics content knowledge and student achievement for all 48 participants in the study. Questions 2B did not address any

differences with respect to the relationship between mathematics content knowledge and student achievement at the middle or high school level. Given that this information can be culled from the data set and could inform various findings of this study or future research, an analysis has been conducted below.

The research question that addresses this query is “To what extent are there differences in the relationship between a teacher’s mathematics content knowledge and student achievement based on whether or not the teacher teaches Algebra I at the middle school or high school level?”

Separate bivariate correlations were conducted using SPSS to determine the extent of the difference between middle and high school teachers with respect to their mathematics content knowledge, as measured by certification level reported on the TSESMI survey, and student achievement, as measured by the EOC Algebra I SOL. Data in Table 12 reveal there is no significant relationship between a teacher’s mathematics content knowledge and a student’s achievement at the middle school level ( $r = -.143$ , n.s.); meaning that the teacher’s mathematics content knowledge is not related to the student’s achievement on the Algebra I SOL at the middle school level. The data in Table 12 reveals a lack of a relationship between the variables at the high school level ( $r = .041$ , n.s.). This data does not demonstrate a statistically significant relationship between a teacher’s mathematics content knowledge and a student’s achievement at the high school level; meaning that the teacher’s mathematics content knowledge is not related to the student’s achievement on the Algebra I SOL at the high school level.

### Research Question Three

*To what extent are Algebra I teachers' self-efficacy beliefs for mathematics instruction related to mathematics pedagogical knowledge?*

Mathematics pedagogical knowledge can be measured in several different ways.

Chapter 3 outlines the various ways in which it can be measured. For the purposes of this study, mathematics pedagogical knowledge was determined using questions 20 through 24 on the TSESMI Survey (Cronbach's Alpha = .650). Table 16 outlines TSESMI questions 20 through 24.

Table 16

#### *Mathematics Pedagogical Knowledge Questions from the TSESMI Survey*

| Number | Question from TSESMI Survey   |
|--------|---|
| 20     | How would you rate your knowledge of the use of manipulatives such as Algebra tiles in the Algebra classroom?   |
| 21     | How would you rate your knowledge of the use of the graphing calculator in the Algebra classroom?               |
| 22     | How would you rate your capacity to explain Algebra vocabulary?   |
| 23     | How would you rate your ability to make use of a variety of grouping practices in the Algebra classroom?        |
| 24     | How would you rate your use of strategies to differentiate for varying levels of student knowledge and/or need? |

To explore the possible relationship between a teacher's self-efficacy beliefs and mathematics pedagogical knowledge, as measured by questions 20-24 on the TSESMI survey, an independent bivariate correlation was completed using SPSS. The data in Table ABC reveal a positive linear relationship between the variables ( $r = .412$ ,  $p < .01$ ). There is a statistically significant relationship between a teacher's self-efficacy beliefs and mathematics pedagogical knowledge. Additionally, as the correlation is positive, this data provides evidence that teachers who have a higher sense of self-

efficacy exhibit a higher level of pedagogical knowledge in mathematics. Table 11 outlines the data for this finding

**Question 3A:** *Does teacher mathematics pedagogical knowledge differ significantly in the middle school versus the high school?*

In order to determine if there was any difference in the mathematics pedagogical knowledge of teachers at the middle school level versus the high school level, an independent samples *t*-test was conducted using SPSS. The mean score for the mathematics pedagogical knowledge of middle school teachers was  $M=3.56$  ( $SD=.555$ ) and the mean score for the mathematics pedagogical knowledge of high school teachers was  $M=3.75$  ( $SD=.476$ ). A statistical difference was shown between the two means  $t(46) = 2.30, p<.05$ , indicating that teachers at the high school level in this study had higher mathematics pedagogical knowledge, as measured by responses to questions 20-24 on the TSESMI survey, than did the teachers at the middle school level. Table 17

Table 17

*Group Statistics for Middle School versus High School Mathematics Pedagogical Knowledge*

| Level                                     | N  | Mean | Standard Deviation |
|---|----|------|--------------------|
| Middle School Math. Pedagogical Knowledge | 13 | 3.56 | .555               |
| High School Math. Pedagogical Knowledge   | 16 | 3.75 | .476               |

**Question 3B:** *To what extent is Algebra I teachers' mathematics pedagogical knowledge correlated to student achievement in Algebra I?*

To examine the extent of the relationship between a teacher's mathematics pedagogical knowledge, as measured by questions 20-24 on the TSESMI survey, and student achievement, as measured by the EOC Algebra I SOL, an independent bivariate

correlation was completed using SPSS. The data in Table 11 reveals a non-significant relationship between the variables ( $r = -.112$ , n.s.). There is a no relationship between a teacher's pedagogical knowledge and student achievement, meaning that a teacher's mathematics pedagogical knowledge is not related to student's achievement.

**Auxiliary finding.** Questions 3B asked specifically inquires about the extent of the relationship between a teacher's mathematics pedagogical knowledge and student achievement for all 48 participants in the study. Questions 3B did not address any difference with respect to this relationship at the middle or high school level. Given that this information can be culled from the data set and could inform various findings of this study or future research, an analysis has been conducted below.

The research question that addresses this query is "To what extent are there differences in the relationship between a teacher's mathematics pedagogical knowledge and student achievement based on whether or not the teacher teaches Algebra I at the middle school or high school level?"

Separate bivariate correlations were conducted using SPSS to determine the extent of the difference between middle and high school teachers with respect to their mathematics pedagogical knowledge, as measured by responses to questions 20-24 on the TSESMI survey, and student achievement, as measured by the EOC Algebra I SOL. The data in Table 12 reveals there is no relationship between the variables at the middle school level ( $r = .393$ , n.s.). This data does not demonstrate a statistically significant relationship between a teacher's mathematics pedagogical knowledge and a student's achievement at the middle school level; meaning that the teacher's mathematics pedagogical knowledge is not related to the student's achievement on the Algebra I SOL

at the middle school level. The data in Table 12 reveals there is no relationship between the variables at the high school level ( $r = -.111$ , n.s.). These data does not demonstrate a statistically significant relationship between a teacher's mathematics pedagogical knowledge and a student's achievement at the high school level; meaning that the teacher's mathematics pedagogical knowledge is not related to the student's achievement on the Algebra I SOL at the high school level.

### **Summary**

The primary purpose of this quantitative study was to investigate the relationship between teacher self-efficacy beliefs and student achievement, as measured by the 2010 or 2011 Algebra I EOC SOL. The data revealed that a teacher's self-efficacy beliefs did not significantly relate to student achievement. The study also explored the association between teacher self-efficacy and student achievement to mathematics content and pedagogical knowledge. There was no statistical significance to support a relationship claim between teacher self-efficacy, student achievement and content knowledge. An important findings, however, was that a bivariate correlation provided evidence that a statistically significant relationship did exist between teacher self-efficacy beliefs and mathematics pedagogical knowledge ( $r = .412$ ,  $p < .01$ ). There was no correlation between mathematics pedagogical knowledge and student achievement.

Additionally, this study chose to examine these same four variables, teacher self-efficacy, mathematics content knowledge, mathematics pedagogical knowledge and student achievement, at two different levels of instruction – the middle school and the high school. There are statistically significant differences for all four variables, with teacher self-efficacy, mathematics content knowledge and mathematics pedagogical

knowledge having higher means at the high school level, while student achievement had a higher mean at the middle school level.

## CHAPTER 5: CONCLUSION

Given the importance of student success in Algebra I in Virginia, the mandates of NCLB, and the renewed push to prepare students for a competitive global market, it is important to have teachers in our schools who are motivated by the belief they can impact student achievement. Therefore, investigating the construct of teacher self-efficacy is a worthwhile endeavor. “The task of creating learning environments conducive to the development of cognitive competencies rests heavily on the talents and self-efficacy of teachers” (Bandura, 1997, p. 240). This belief, teacher self-efficacy, has been explored in previous research and a relationship has been identified between the self-efficacy beliefs of a teacher and student achievement (Tschannen-Moran, et. al, 1998; Wheatley, 2002). The art of teaching is complex, with many variables in play at one time. In addition to teacher self-efficacy and student achievement, two other variables that may influence an Algebra teacher’s behaviors in the classroom are mathematics content knowledge and mathematics pedagogical knowledge. Does the teacher know the content and does the teacher know how to teach the content to students?

The purpose of this study was to expand upon the research base in the area of teacher self-efficacy and its relationship to student achievement, mathematics content knowledge, and mathematics pedagogical knowledge. Exploring the potential relationships between teacher self-efficacy, mathematics content knowledge, mathematics pedagogical knowledge, and student achievement serves to inform educators who work with pre-service teachers in designing their course of study as they enter the field of education, and it places school leaders in a position to better plan professional



development, enhance teacher mentor programs, and provide resources to assist in the development of practicing teachers.

This study also chose to delve into the difference between Algebra I instruction at the middle school versus the high school level, within the context of the four variables presented. The differences that could be culled from the data to help school leaders better inform their practices as they prepare teachers for these different classrooms were examined. Algebra I is considered a gatekeeper course in the state of Virginia. A student cannot graduate with a standard or advanced diploma without passing Algebra I, thus it is important and relevant to study the unique dynamics of these teachers so as to ensure students can earn a high school diploma.

### **Results**

This study revealed no significant relationship found between teacher self-efficacy and student achievement, as measured by the EOC Algebra I SOL; nor was there a significant correlation found between teacher self-efficacy and mathematics content knowledge, as measured by teaching certification. Correlational analysis confirmed a moderate positive relationship existed between teacher self-efficacy beliefs and mathematics pedagogical knowledge.

There was no significant relationship found between mathematics content knowledge and student achievement. Correlational analysis did not reveal a relationship between mathematics pedagogical knowledge and student achievement.

There was a statistically significant difference in means between high school and middle school teachers for all four constructs under study - teacher self-efficacy beliefs,

mathematics content knowledge, mathematics pedagogical knowledge and student achievement.

With respect to the findings specifically related to the middle school or high school level and student achievement, no significant relationships were found for the any of the four constructs under study

### **Discussion of the Results**

#### **Teacher Self-Efficacy and Student Achievement**

The results of this study did not demonstrate a correlation between teacher self-efficacy beliefs and student achievement. There may be number of reasons why it is possible that the original hypothesis for this study, that the teacher's level of self-efficacy impacts the achievement of his or her students, may be incorrect. Some of these reasons may have to do with the instrument itself, the behaviors of the teacher or the development of the teacher's self-efficacy beliefs.

While much of the prior research presented articulates a relationship exists between teacher self-efficacy and student achievement (Anderson et al., 1988; Armor et al., 1976; Ashton & Webb, 1986; Berman et al., 1977; Ross, 1992; Schwackhammer, 2009), there are studies that did not find evidence of a relationship between teacher self-efficacy and student achievement. For example, Brown, Molfese and Molfese (2008) found that teacher self-efficacy did not demonstrate a positive effect on student success when they studied pre-school teachers and student achievement in mathematics numeration. Capraro et al. (2006) hypothesized that teacher self-efficacy would influence job satisfaction of teachers, which would in turn have a beneficial effect on student

success. They did find that teacher self-efficacy was correlated to job satisfaction, but this finding did not contribute to an increase in student achievement.

In general, the references in research to a teacher's self-efficacy impact on student achievement span various content areas and grade levels. It is not uncommon to find research studies involving teacher self-efficacy begin their commentary with a statement such as "numerous research studies have indicated a positive correlation between teacher self-efficacy and student outcomes, such as student achievement." This infers that this relationship holds true across various grade levels and content areas. For example, the Armor et al. (1976) study is frequently referenced in research regarding the correlation of these two variables; however, the relationship existed only in the area of reading achievement.

Mathematics is very different from reading, so it would be plausible to assume that a relationship that was found in the area of reading may not be found in the area of mathematics. The current study illustrates that it may not be acceptable to generalize the positive correlations previously found between teacher self-efficacy and student achievement to all content areas and to all grade levels. Assumptions made about study comparisons may be inappropriate (Ross, 1992).

Anderson, Greene and Loewen (1998) found that in third grade a teacher's sense of efficacy appeared to be a significant factor in student achievement, but the same could not be said for teachers at the sixth grade level. The study reasoned that at the sixth grade level, teachers' influence over student learning began to diminish (Anderson et al., 1988). This could be the argument in this study as well. While not statistically significant, the relationship between teacher self-efficacy and student achievement at the middle school

level ( $r = .354$ , n.s.) was somewhat higher than at the high school level ( $r = .175$ , n.s.). It may be possible that teacher self-efficacy beliefs are harder to flush out at the secondary level because there is an underlying assumption on the part of teachers that the older a student is, the less control the teacher may have over the student's learning?

It may be possible that no significant correlation was found in this study between these two variables because the complexity of mathematics increases as students get older and the potential lack of understanding of basic concepts begins to have cumulative effect. Many of the studies that found a relationship between teacher self-efficacy and student achievement took place in the elementary school setting, whereas the current study took place at the middle and high school level.

Given that elementary math is of a more simplistic nature conceptually, the teacher's efficacy may be more closely related to the achievement of the students. In the Anderson et al. (1998) study, researchers found that the third grade teacher's self-efficacy beliefs were a significant factor in student achievement but the same could not be said for teachers at the sixth grade level. Math at the Algebra I level is more complex. An Algebra I teacher may feel he or she can impact the student's learning in Algebra I by teaching them Algebra I concepts, but the student then scores poorly on assessments because they have a cumulative lack of understanding for basic mathematics concepts. The student might be able to move through the algebraic process of solving for a variable in a problem, but not understand how to add or subtract negative numbers; thus the student gets the problem incorrect on an assessment. Therefore, at the higher levels of mathematics we may begin to see the correlations between the variables weaken or disappear due to the sheer nature of the content becoming more complex. One way to

investigate this may be to conduct longitudinal studies utilizing the TSESMI across other grade levels or math content areas.

Mathematics is a very conceptual field, often requiring the learner to be able to understand material that is not tangible or in many cases immediately relevant to students. Mathematics can be a very difficult and challenging area of study for many. Mathematics in America is being taught on a very technical or procedural level (TIMSS, 2007), with most teachers demonstrating how to solve problems, rather than digging into the deeper theoretical underpinning of mathematics.

The lack of a correlation between teacher self-efficacy and student achievement may be the result of a disconnect in the cognitive processes needed to inform a teacher's efficacy beliefs. The process of self-efficacy development is cyclical; there are opportunities for teachers to develop new beliefs based on experiences and reshape their teaching. This reflection on practice is critical to the art and science of teaching, and is needed to ensure that what is being taught reflects the needs of the students.

In the development of teacher's self-efficacy beliefs, there is a need to cognitively process the sources of one's efficacy in relation to the analysis of the task and the assessment of personal teaching efficacy. As the teacher is thinking about his or her abilities with respect to the mathematical task they must perform, they may be processing their abilities from a purely procedural standpoint, which leads to a high level of self-efficacy (i.e. "I can teach my students to solve for a variable"). The teacher then teaches the student from this procedural frame, possibly not presenting the conceptual frame; thus rendering student learning incomplete. In order for the student to correctly answer a question on an assessment, a theoretical level of understanding may be required. The

student may or may not be able to answer the question correctly based on his or her overall understanding.

If the teacher is not thoughtful as to the student's outcomes and the impact of their teaching, then he or she is not bringing new sources of efficacy into the development process; therefore, no changes will be made and the teacher will continue to believe that he or she is a highly efficacious teacher. The teacher will continue to instruct in the same manner they always have, possibly garnering the same level of achievement.

Additionally, in reference to the cyclical nature of the development of self-efficacy, Wheatley (2002) writes that the desire to impact students is central to most teacher's motivation to teach; doubts about one's efficacy will often be the most potent type of doubt required to foster true change in the teaching practice. Having doubts can be beneficial because reflecting on one's abilities and self-efficacy can lead to new insights and understandings (Tschannen-Moran & Johnson, 2011).

In instances where there is a disconnect between the self-efficacy beliefs and student achievement, it is possible to consider that the teacher has little or no doubts in his or her ability to impact students; however, student outcomes tell a different story. With the development of self-efficacy being a cyclical process that relies on reflection of performance to provide new sources of efficacy information for the teacher, beliefs about teaching are likely to remain unless there are some experiences that cause the teacher to reassess his or her beliefs. Not reflecting on practice because you have no doubt that what you are doing is "working" for students, does not allow for new sources of self-efficacy to develop. This can lead to teachers not adjusting their teaching to the ever-evolving needs of his or her students or the changes in curriculum.

Teacher self-efficacy is a motivational construct – meaning that if a person believes that he can do something, he will likely perform the actions needed to accomplish the task. As a motivational construct it influences the thought patterns and emotions that enable actions in which one might contribute considerable effort in the pursuit of goals, persist in the face of adversity, or rebound from temporary setbacks (Bandura, 1986, 1997). Teacher self-efficacy is also considered a “self-referent” construct as it relies on the teacher to estimate his or her own level of efficacy (Pajares, 2002). It is a self-perception not an objective measure of teaching effectiveness (Ross & Bruce, 2007). Over- or underestimating self-efficacy can have consequences for the course of action they choose to pursue or the effort they exert (Tschannen-Moran et al., 1998). It is possible for a teacher to report a high level of self-efficacy but her students demonstrate a low level of achievement. There is the risk that teachers may have over-reported their perceptions about the use of various strategies and there is no way to tell if they are being used properly.

However, it is possible that the perceived efficacy beliefs a person holds are not supported by requisite knowledge and skills needed to contribute considerable effort, pursue goals, persist in the face of adversity, or rebound from temporary setbacks. High efficacy will not produce competent performance in the absence of necessary skill and knowledge (Marat, 2007). So it possible that there is no correlation between teacher self-efficacy and student achievement because the teachers in the study believed they had the necessary skills and knowledge needed to impact student learning, but they could not demonstrate the behaviors in the classroom that translated into increased learning outcomes for students. It is possible that teachers know the content and the pedagogy for

mathematics but do not know how to apply it in the classroom. This may lead to a lack of achievement.

This consideration is evidenced by the data from this study. In this study, the high school teachers' mean self-efficacy score ( $M = 6.95$ ,  $SD = .916$ ) was higher than that of the middle school teachers ( $M = 6.36$ ,  $SD = 1.05$ ); however, the high school teachers' overall average scaled score for mathematics achievement ( $M = 455$ ,  $SD = 33.7$ ) was lower than that of the middle school teachers ( $M = 499$ ,  $SD = 28.5$ ).

The fact that self-efficacy is self-referent should not be interpreted in a negative light. There is no other way for researchers to garner information about teacher's beliefs other than teachers assessing those beliefs from the teachers themselves. This brings to light the issue of calibration or the accuracy of self-efficacy beliefs with a teacher's actual performance. Without witnessing the actual behaviors and actions of the teacher in the classroom, it is difficult to determine how the teacher's self-efficacy beliefs align with the teacher's behaviors in the classroom. Future study in the area of teacher self-efficacy and student achievement should consider having a component where teachers are observed in the classroom to determine the specific behaviors they are displaying. Additionally, researchers should consider conducting assessments of teacher self-efficacy over-time, as the continual self-assessment of self-efficacy can aid in the over- or under-inflation of self-efficacy beliefs (Moore & Cha-Jan Chang, 2009; Schmidt & DeShon, 2009).

McLaughlin and March (1978) found a chain that linked teacher self-efficacy to student achievement. This chain illustrated that teacher self-efficacy impacted the behaviors the teacher exhibited in the classroom, which in turn impacted the student's efficacy, which influenced the student's behaviors and these behaviors then impacted the



student achievement. This places four degrees of separation between student achievement and teacher self-efficacy. Given the distance between teacher self-efficacy and student achievement, it is quite possible that the two variables are unrelated. It would be of interest to investigate the intermediary variables to determine their impact on student achievement.

Another factor to consider when seeking to understand why no relationship was found between teacher self-efficacy and student achievement is that the self-efficacy of a teacher can lead to behaviors which create changes in student perceptions about their academic abilities (Ross, 1992) or the student's self-efficacy beliefs for mathematics. While this study did not investigate student self-efficacy, it is a viable consideration, especially for the conceptually complex content area of mathematics. Just like teacher self-efficacy, a student's level of efficacy impacts the effort and persistence they give and the goals they set. If a student does not feel very efficacious for mathematics, then they may not achieve no matter the level of the teacher's self-efficacy.

With the survey being administered at the end of not only the Tidewater Team program but at the end of the school year, "school year fatigue," may have set in and teachers may not have given the survey their full attention. This is evidenced by one teacher who left more than half of the questions blank on the survey and one teacher who selected the highest, most efficacious responses for each question on the survey. This may have impacted the mean scores calculated for teacher self-efficacy. Having a larger sample size or removing these outliers from the overall mean may impact the overall findings.

Additionally, it should be noted that there are contextual differences between the students at the middle and high school level, and these difference may impact the student achievement data that is used in this study. Students at the middle school level are highly efficacious (Hines & Kristonis, 2010) and there is research that suggests that this impacts student achievement (Ross 1998). Algebra I is considered a ninth grade math course; however, in Virginia, students can take Algebra I in seventh or eighth grade. This puts these students either one or two year above grade level with respect to math. These students are traditionally more academically focused and motivated, and they anticipate taking higher level math courses, such as Calculus, in high school. Many of these students earn advanced studies diplomas are normally found in your advanced placement courses at the high school level.

In comparison, students who are taking Algebra I at the high school level fall into two categories – those who are on grade level or those who are below grade level in their study of mathematics. Students who do not complete Algebra I at the middle school level have had three years of pre-algebra study or may have attempted Algebra I in eighth grade, but were not successful. These students would be considered on grade level for mathematics. Students who are below grade level for mathematics are those who have previously taken and not been in successful in Algebra I and are not in the ninth grade or are repeating the ninth grade. Whether on grade level or below grade level, the student who is taking Algebra I in high school is, in general, not as academically focused or motivated in comparison to the top tier of his or her peers. These students are most likely working toward a standard diploma and will most likely not take advanced level math courses, such as Calculus, in high school. These students certainly can take higher level

math courses, as most course sequences allow for a student who begins Algebra I in high school to complete Calculus during their senior year.

As students in the middle school are one to two years above grade level in mathematics, one would assume they would score more proficiently on a minimum competency examination such as the EOC Algebra I SOL. Evidence from this study would indeed reflect this. At the middle school level, the average scaled scores for 13 of the 20 teachers (65%) were in the pass advanced range. Comparably, at the high school level only three of 28 teachers (11%) had average scaled scores that were at the pass advanced level. Do the teachers of middle school students have a higher mean average scaled score than the high school teachers because of the type of student they teach? Further investigation into this is needed and a larger sample size would help provide a more thorough analysis.

Additionally, this contextual difference in student may also impact the self-efficacy of the teachers. The mean for teacher self-efficacy is higher at the high school level than it is at the middle school level. Aerni (2008) suggests that it might be possible that the middle school teacher's self-efficacy was lowered as a result of teaching highly gifted students who may challenge their level of mathematics knowledge by asking questions the teacher may not be able to answer or providing alternate methods of problem solving that the teacher may not understand; whereas, the high school teachers may assume that many their students only understand mathematics at a basic level and would therefore not challenge them by asking difficult questions or developing alternate methods for problems solving. In other words, the high school teacher believes at a

higher level than middle school teacher that they are ready to handle anything the students might throw their way with respect to mathematics.

It is possible that there was no correlation between teacher self-efficacy and student achievement as there was only one measure for obtaining the student achievement data. The measure of student achievement used in this study was the average scaled score for the EOC Algebra I SOL for each teacher. Are standardized measures of achievement the best way to garner information about the relationship between teacher self-efficacy and student achievement? While they are easy to administer and they can allow for comparison across many areas, they only provide a static, one-time evaluation of learning. It would be advantageous to look at additional ways of assessing student achievement for correlational research such as this. Might it be beneficial to include more than one measure of assessment when evaluating the self-efficacy and achievement relationship? Perhaps classroom grades could be considered for use, but their use would require careful discussion about validity and reliability. Would measures of progress be more suitable? There are a number of additional research opportunities to explore with respect to this avenue. This study used only one measure as the data was from extant work done through the Tidewater Team for Mathematics Instruction.

Much of the seminal work that was conducted to illustrate the link between teacher self-efficacy and achievement was done using instruments that measured a teacher's self-efficacy for teaching, not the teacher's efficacy for mathematics teaching. The fact that self-efficacy for the teaching of mathematics is much more complex than teaching in general, could account for the fact that there was no correlation between teacher self-efficacy and student achievement found in this study. Additional studies need

to be conducted with instruments, including this one, that are very specific to the teaching task to determine if student achievement and teacher self-efficacy are indeed correlated for specific disciplines.

Teacher self-efficacy has been described as a psychometrician's nightmare as it is a conceptually appealing variable that is predictive of and highly related to a multitude of other critically important variables such as teachers' classroom management strategies, referral to special education, program implementation effectiveness and the adoption of innovation (Guskey, 1998). It is also a variable fraught with measurement dilemmas.

The self-efficacy measure used in this study, the Teacher Self-Efficacy Scale for Mathematics Instruction (TSESMI) was adapted to specifically ascertain the self-efficacy beliefs of mathematics teachers and was modeled after the Teacher Self-Efficacy Scale (TSES) developed by Tschannen-Moran and Hoy (2001). This study represents the first use of the TSESMI, and the only study to use it to explore potential relationships between teacher self-efficacy, mathematics content knowledge, mathematics pedagogical knowledge, and student achievement. The TSESMI survey was reviewed by a panel of 20 experts comprised of math educators, math supervisors, university professors, and mathematics practitioners. The Cronbach's alpha score (.94) was high for the reliability of the teacher self-efficacy questions in the TSESMI. However, outside of the conceptual underpinnings for the construct of teacher self-efficacy, it is possible that the instrument itself is the reason there was no correlation between teacher self-efficacy and student achievement.

A large number of research studies regarding teacher self-efficacy have been conducted using the TSES. There are also studies that have used the Gibson and Dembo

(1984) Teacher Efficacy Scale (TES) instrument. The evidence for the relationship between teacher self-efficacy and student achievement has been made based on the use of these instruments. The finding of a statistically non-significant relationship between the variables of student achievement and teacher self-efficacy in this study was found using only the TSESMI. Until further testing is completed with the new TSESMI instrument, it would not be fair to rule out any relationship between teacher self-efficacy and other variables, and it would also not be prudent to make any assertive comparisons regarding the findings gleaned from these studies. The TSES and TSE measure the efficacy a teacher has for teaching in general, while the TSESMI measures the specific efficacy a teacher has for teaching mathematics. Given that these measures are looking at different contexts, it would be valuable to give both the TSES and the TSESMI to teachers for comparative and statistically purposes.

There is a great deal to consider when working toward an understanding of the relationship between teacher self-efficacy and student achievement and continued research in this area will only continue to illuminate the important construct of teacher self-efficacy.

### **Mathematics Content Knowledge**

Mathematics content knowledge, or the knowledge typically acquired through the formal education process, was not found to be correlated to both teacher self-efficacy and achievement. The previous research findings on the relationship between mathematics content knowledge and self-efficacy have been mixed. Schwackenhammer et al. (2009) found that teacher's self-efficacy was higher for those teachers who had taken four or more math content courses. However, Swars et al. (2007) found that mathematics was

not related to teacher self-efficacy. Tschannen-Moran and Johnson (2011) found that having attained a higher degree of education was unrelated to self-efficacy.

Earlier, it was discussed earlier that self-efficacy is a self-referent construct in which the possibility exists for teachers to over or under estimate their beliefs in relation to the actual skills they can demonstrate. In that same vein, it is possible for a teacher to indicate a high level of self-efficacy but demonstrate a low level of mathematics content knowledge. Conversely, a teacher can report low self-efficacy beliefs but have a high level of mathematics content knowledge. As a teacher, I may feel that I know a great deal of mathematics and understand the complexities of the subject at a conceptual level, but I am not able to demonstrate this knowledge by and through various assessments or courses that are built around this knowledge.

“Studies over the past 15 years consistency reveal that the mathematical knowledge of many teachers is dismayingly thin” (Ball, Hill & Bass, 2005). Remedies that are often proposed to help improve the level of content knowledge of teachers are to require teachers to study more mathematics or to have teachers hold degrees in mathematics in order to become a teacher (Ball, Hill & Bass, 2005). “To provide students with highly qualified teachers, NCLB requires teachers to demonstrate subject-matter competency through subject specific majors, certifications, and other means” (Hill et al., 2005, p. 371). The changes of NCLB have been in place for more than ten years, yet this study indicates that there is no correlation between the mathematics content knowledge of a teacher and the achievement of students.

Perhaps the disconnect goes back to a discussion in the previous section about the way in which mathematics is being taught. Mathematics instruction in the United States

is very procedurally or technical in its orientation. While there are conceptual components imbedded in this instruction, the overarching tenants of the instruction are not prioritized from a theoretical bent. This is producing teacher candidates who understand mathematics in a procedural way. In turn these students become the teachers and educate the next crop of students in the same manner. It would appear that this cycle has persisted for a long time. Perhaps the answer is not to require more math classes or majors in the area of mathematics; perhaps the answer is to augment the way we teach mathematics to develop more conceptual thinkers who can explain the theoretical underpinnings of mathematics to students in the classroom.

Another proposed remedy is to hire teachers from highly selective colleges that have demonstrated a strong aptitude for mathematics as well as high levels of achievement in mathematics (Ball, Hill & Bass, 2005). However, this could be problematic. Understanding mathematics content at a very high level does not equate to being able to teach mathematics at a very high level or being able to impact student outcomes such as achievement. The art and science of teaching is so complex and involves so many different knowledge and skill sets. Content knowledge is an important component of teaching, but it is unacceptable to assume that knowing mathematics would be the only prerequisite to being an effective teacher of mathematics.

Earlier research findings on the relationship between mathematics content knowledge and achievement also varied. Ball et al., (2005) found that teachers who answered more questions correctly on a mathematics content-knowledge assessment had students who had higher achievement gains over the course of school year; while Begle (1972) and Eisneberg (1977) both found that a teacher's knowledge of algebra did not



significantly correlate with a student's academic performance. Having the prerequisite level of knowledge, regardless of how that is defined, does not guarantee that a teacher will be able to turn that knowledge into student learning that produces achievement gains.

In fact, this assertion is evidenced by the significant negative correlation found in this study between mathematics content knowledge and mathematics pedagogical knowledge ( $r = -.308, p < .05$ ). This negative correlation indicates that the higher the level of content knowledge, the lower the teacher's level of pedagogical knowledge. Many of us can relate to the experience of having a classroom teacher who is book-smart, but unable to relate the curriculum to the students. This paradigm results in students who are confused and frustrated.

One area that warrants additional consideration is that of the methods used to determine the level of a teacher's content knowledge. The National Math Advisory Panel (2008) identified three ways in which the content knowledge of a teacher could be measured: (1) teacher certification; (2) mathematics course work; and (3) tests of teachers' mathematical knowledge. This study utilized only teacher certifications as its measure, so it would make sense to try to maximize results of further study by adding both a component to assess the mathematics course work of the teacher and an assessment of the teacher's mathematics knowledge.

Individuals seeking an initial Virginia licensure must have: (1) passed the Virginia Communication and Literacy Assessment (VCLA) with a score of at least 235 in the areas of Reading and Writing or have a cumulative score of at least 470; (2) passed the Praxis II, a content assessment; and (3) completed the course requirements for their content area. If this study or one similar to it were to be replicated in Virginia, all three

of the content knowledge measures outlined by the National Math Advisory Panel would be obtainable, and, if possible, should be used as a measure for content knowledge.

The Algebra I teacher candidate must take and pass the Praxis II specialty area test in the area of Mathematics with a score of 178 or higher (VDOE, 2011). The Education Testing Service [ETS] (2011) reports that the Praxis II: Mathematics assessment is a norm-referenced specialty area assessment that measures subject specific content knowledge in mathematics. The Praxis II also offers a criterion referenced portion that could be used to assist teachers by providing a needs-assessment to aid teachers in improving their overall content knowledge.

Having Praxis II scores would allow teachers to be differentiated into tiers based on their scores. This means that some teachers may have passed with a 178, the lowest passing score in Virginia, while others may have passed with a score of 200, the maximum score possible. If using these scores to measure content knowledge, then it could be hypothesized that a teacher with a score of 200 would have a higher level of content knowledge than a teacher with a score of 178. Added to the certification level data, there would now be two measures by which to evaluate a teacher's mathematics content knowledge.

A third measure could be added to the determination of a teacher's mathematical content knowledge – mathematics course work completed. To be eligible for Algebra I licensure in the state of Virginia, a teacher would need to meet the course requirements outlined in Table 18.

Table 18

*Course Requirements for Mathematics Endorsement in Virginia*

| Math 6-12 endorsement  | Algebra Add-On   |
|--|--|
| Graduated from an approved teacher prep program in mathematics | Graduated from an approved teacher prep program in Algebra I   |
| OR   | OR   |
| Completed a major in mathematics                               | Hold a baccalaureate degree from a regionally accredited university AND an endorsement in a teaching area AND completed 24 hours of coursework that include the following areas: |
| OR   |  |
| 36 semester hours of course work in the following areas:       |  |
| Algebra  | Elementary functions   |
| Geometry   | Trigonometry   |
| Analytic Geometry  | Linear Algebra   |
| Probability and Statistics                                     | Euclidean Geometry   |
| Discrete Math  | Probability and Statistics   |
| Computer Science   | Discrete Math  |
| Calculus   | Computer science   |
|  | Calculus   |

Teachers must present an official college transcript outlining the courses they have completed in order to ascertain whether or not endorsement requirements have been met. To add even more information to the teacher's level of mathematics content knowledge, a review of the teacher's grades in mathematics content courses would provide the researcher with additional insightful information. While it may be tedious to obtain all three of three pieces of information - teacher endorsement, Praxis II scores, and grades for mathematics content area courses – it would provide a more circumspect evaluation of a teacher's mathematics content knowledge for deeper statistical analysis and subsequent identification of construct relationships.

Additionally, there was one interesting find in the data – of the teachers at the high school level who participated in the study, three of these teachers had only an elementary plus endorsement. This means that none of the three held the required Algebra Add-on endorsement or the Math 6-12 endorsement needed to teach algebra; it can only be assumed that these three teachers had been given a provisional license to teach the course. Table 19 outlines additional data regarding these three teachers.

Table 19

*Data for Three High School Teachers with Elementary Endorsement*

|   | Teacher A  | Teacher B   | Teacher C      |
|---|--|---|----------------|
| Teacher Self-Efficacy Rating (Scale 1-9)            | 7.29   | 7.13  | 8.47           |
| Mathematics Pedagogy Rating (Scale 1-5)             | 4.20   | 4.00  | 4.00           |
| Student Achievement Scaled Score Mean (Range 0-600) | 422  | 405   | 559            |
| Certification                                       | Elementary K-8<br>Middle 4-8<br>Middle school math | Elementary K-8<br>Pre-K – 6<br>Middle school math | Elementary K-8 |
| Gender  | Male   | Male  | Female         |
| Years Teaching                                      | 2  | 4   | 6              |

Other than the fact that these three teachers were teaching at the high school level with an elementary endorsement, what makes this data interesting are the scores the teachers had for their self-efficacy, mathematics pedagogical knowledge and average scaled scores. With an average scaled score of 559, one of these three teachers had the

highest average scaled score for all 48 study participants. A score of 559 represents a pass advanced score on the SOL and the second highest self-efficacy rating for all 48 participants. The lowest and second lowest average scale score for all study participants, 405 and 422 respectively, belonged to the other two teachers with elementary endorsements. All three of these teachers had teacher self-efficacy and mathematics pedagogy scores in the upper third of all participants. Interestingly enough, these three teachers had only been teaching for 2, 4 and 6 years. It should be noted that there is no other information available regarding the students who were in this teacher's class; for example, it is not known how many students were in the class or if they were first time or repeating Algebra I students.

Is there something to having teachers with elementary training teaching students at the high school level? As shared earlier, students at the high school level are typically less motivated and may have struggled with math in the past. These students often respond well to a very hands-on approach to learning. Teachers with an elementary background are typically more adept at utilizing various instructional strategies or manipulatives in the classroom because of the training they receive as students in elementary education programs.

For mathematics pedagogical knowledge, the overall mean for all 48 teachers in the study was  $M = 3.71$  and the mean for all high school teachers was  $M = 3.85$ . The mean for mathematics pedagogical knowledge for the three teachers with elementary endorsements at the high level was  $M = 4.07$ . This is considerably higher than the overall mean for all teachers in the study and the mean for the high school teachers. This

suggests that the teachers with an elementary background held stronger beliefs that they were able to utilize manipulatives, graphing calculators, or explain Algebra vocabulary.

Additionally, for self-efficacy beliefs, the overall mean for all teachers in the study was  $M = 6.70$  and the mean for the high school teachers it was  $M = 6.94$ . The mean for self-efficacy for the three teachers with elementary endorsements at the high school level was  $M = 7.63$ . This tells us that these three teachers held strong beliefs that they could execute the actions needed to teach Algebra I, and their beliefs were stronger than those of their teaching peers.

The information shared about these three teachers provides insights that encourage future research to look at this interesting dichotomy more deeply – what can elementary teachers teach us about teaching mathematics at the high school level and what is it about the way that elementary teachers teach that may be of benefit to the high school Algebra I student?

### **Mathematics Pedagogical Knowledge**

This study did find a statistically significant correlation between teacher self-efficacy and mathematics pedagogical knowledge ( $r = .412, p < .01$ ). Mathematics pedagogical knowledge was measured by TSESMI questions 20-24. Those teachers that perceived themselves as having strong knowledge of mathematics pedagogical skills and strategies, have a higher sense of self-efficacy. Pedagogical knowledge goes beyond the knowledge of the subject matter to include ways of presenting and formulating the subject matter to make it more comprehensible to the student (Shulman, 1986). Given that self-efficacy beliefs manifest into the actions of the teacher, it is likely the behaviors of the teacher in the classroom, with respect to pedagogy, provide the link between self-

efficacy and mathematics pedagogy. The time spent studying mathematics pedagogy, either as a pre-service teacher, novice or experienced teachers, leads to a higher self-efficacy, and teachers' with a higher level of self-efficacy have a propensity to be innovative and try new instructional methods that specifically meet the needs of his or her students (Allinder, 1994; Berman et. al., 1977; Guskey, 1981; Stein & Wang, 1988).

Teachers who had a high sense of self-efficacy in this study indicated that they perceived themselves as behaving in a manner that includes being excellent or above average in the use of pedagogical strategies such as

- the use of manipulatives, such as Algebra tiles;
- knowledge for the use of the graphing calculator in the Algebra classroom;
- their capacity to explain Algebra vocabulary;
- their use of various grouping practices in the Algebra classroom; and
- their use of strategies to differentiate for varying levels of student knowledge or need.

The finding from this study support previous research conducted to determine if there was a correlation between teacher's pedagogical knowledge and their self-efficacy beliefs. This research has established a robust relationship between a teacher's sense of self-efficacy and instructional strategies in the classroom (Swars et al., 2007; Riggs & Enoch, 1990). Teachers who have spent more time studying the pedagogical methods specific to the content area, typically have higher self-efficacy (Utley, Bryant & Moseley, 2005). Tschannen-Moran and Barr (2004) found that highly efficacious teachers demonstrate the effective use instructional strategies.

An interesting finding developed from this study between the correlation of teacher self-efficacy beliefs and mathematics pedagogical knowledge when looking at teachers who teach Algebra I at the high school versus the middle school level. Overall, the correlation for teacher self-efficacy and mathematics pedagogical knowledge was statistically significant ( $r = .412, p < .01$ ). However, for teachers who teach Algebra I at the middle school level, this correlation was not found to be significant ( $r = .174, n.s.$ ), but was statistically significant for teachers at the high school level for these two variables ( $r = .522, p < .01$ ). Thus, it was the scores of the high school teachers that seemed to show the strongest pattern.

In most secondary mathematics school classrooms, teachers have a very traditional view of teaching mathematics as a fixed body of knowledge to be delivered to students, usually through clear organized presentations and lectures (Swars et al., 2007). Typically, the teacher will lecture on the “mathematical facts” needed for new subject matter, illustrate how these facts play a role in problem solving, and then demonstrate a series of procedural steps to solve various mathematics problems involving the presented facts. With the progression from the middle school classroom to the high school classroom, it is typical to see the level of “traditional” teaching increase.

Given the way instruction is typically delivered and the characteristic differences between students at the middle and high school that were discussed earlier, why would the high school teacher’s mathematics pedagogical knowledge and self-efficacy beliefs be higher? One argument could be that the high teachers understand the type of student they are teaching – a student who in some ways is more challenging to teach because they may not “get it” right away or may not be as diligent with his or her work. These



students can become easily frustrated when they do not understand and are less likely to persist when challenges present themselves; essentially these students have low self-efficacy for mathematics. High school teachers who teach Algebra I may recognize that they have to utilize more “tools” from the instructional toolbox in order to help their students better understand mathematics. This means they have to have a higher level of pedagogical knowledge available to use to be able to meet the needs of their students on a daily basis

In comparison, the middle school teacher is working with students who are advanced in their course of study, and therefore, more likely to understand everything that is being taught to them. They may also have the personal initiative or ability to persist when they do understand by asking the teacher questions, referencing a textbook or going online to find explanations. Given this, one might find that middle school teachers feel less inclined to utilize various instructional strategies because they simple do not need to. If the students understand the material presented from traditional mathematics instructional methods, why would the teacher need to find other ways to develop an understanding of the content?

The behaviors of working to meet the needs of all learners, persisting longer with students who are struggling, and being more likely to use instructional strategies are all behaviors exhibited by teachers who have high levels of self-efficacy (Allinder, 1994; Gibson & Dembo, 1984; Tschannen-Moran & Barr, 2004). It would be of significant interest and value to investigate exactly what instructional strategies middle and high school teachers are using and their perspectives on why they are using them with students.

There is an additional piece of information regarding the data for mathematics pedagogical knowledge and the other study variables. Of the 48 teachers who participated in this study, eight of these teachers participated in the year-long Tidewater Team professional development that provided them with instruction in the both mathematics content and pedagogical knowledge. These eight teachers completed the TSESMI survey at the conclusion of their program.

For these eight teachers, the mean for their self-efficacy beliefs was  $M = 6.83$ , while the overall mean for the self-efficacy beliefs for the remaining 40 teachers was  $M = 6.67$ . While not much higher, it does indicate that the teachers who participated in the professional development program felt themselves more capable to execute the actions needed to successfully teach Algebra I. The research is clear that teaching teachers how to teach increases their self-efficacy (Utley et al., 2005; Swars et al, 2007).

Interestingly enough, these same eight teachers who had participated in the year-long professional development program had a lower overall mean for mathematics pedagogical knowledge ( $M = 3.63$ ) than the other 40 teachers in the study who did not participate in the year-long professional development program ( $M = 3.72$ ). It is not unusual for teachers who have recently participated in professional development to feel less proficient in some areas for the things in which they were just trained. Teachers who enter professional development sessions may feel very adept at using various manipulatives or instructional strategies or feel they know a great deal about teaching a specific content area, unit or skill; but as they progress through training they begin to learn many new things and may feel less adept at utilizing various tools or strategies. It would be of interest to future studies to continue to investigate the dynamic of having

teachers participate in various professional development training, with training on the use of instructional strategies specific to teaching Algebra I, while measuring their self-efficacy beliefs and mathematics pedagogical knowledge pre- and post-training.

### **Mathematics Pedagogical Knowledge and Student Achievement**

Previous research has found that a positive relationship exists between a teacher's level of pedagogical knowledge and student achievement (Hill et al., 2005). The current study did not find a statistically significant correlation between these two variables. High school teachers perceive themselves as having stronger math pedagogical methods than middle school teachers, yet the high school teachers have lower student achievement scores than the middle school teachers. The mean average scaled score for the middle school teachers is  $M = 499$  ( $SD = 28.5$ ), while the high school mean is  $M = 455$  ( $SD = 33.7$ ). This non-significant correlation between mathematics pedagogical knowledge and student achievement may be attributed to fact that only one measure for student achievement was utilized or that the measure was not valid or reliable. The measure for mathematics pedagogical knowledge in this study was five questions on the TSESMI survey asking the teacher to rate themselves as excellent, above average, average, or below average in areas such as using math manipulatives or the graphing calculator, the capacity to explain Algebra vocabulary, and using a variety of grouping strategies. These five questions had a Cronbach's alpha of .640.

This difference in the methods used to assess mathematics pedagogical knowledge could impact the difference in findings. The Hill et al. (2005) study analyzed the teacher's performance on "knowledge of teaching" questions. The more of these knowledge questions a teacher answered correctly ultimately correlated to student

achievement gains (Hill et al., 2005). These knowledge questions were not mathematics specific and the study was only conducted with first- and fifth-grade students. Future studies should examine additional ways of measuring this construct.

### **Directions for Future Research**

In this era of accountability, exploring the construct of teacher self-efficacy is a beneficial endeavor when working to improve student outcomes, even if the findings of this study did not demonstrate a link between teacher self-efficacy and student achievement. Teacher self-efficacy is a valuable and complex construct that correlated with a variety of other variables, and as such, it is replete with opportunities to expand the understanding of these relationships and how these relationships ultimately impact students. This study investigated the relationship between teacher self-efficacy, student achievement, mathematics content knowledge and mathematics pedagogical knowledge. There are immense opportunities to build upon the findings of this study and prior research in these areas.

### **Teacher Self-Efficacy and Student Achievement**

From this study, it is evident that there is a need for additional research studies to further explore the relationship between teacher self-efficacy and student achievement. Does a relationship between teacher self-efficacy and student achievement exist in the mathematics classroom? What will additional research uncover about the relationship of these two variables and the teacher behaviors in the math classroom? Can we differentiate the math teacher's behaviors from those of a generalist teacher in the elementary school? Are there observed differences in the behaviors of math teachers at

the middle school and high school level? In order to answer these questions and others, it might be helpful to look at following when designing studies:

- Test the TSESMI instrument itself – for validity and reliability.
- Run correlations at the elementary, middle and high school levels between the variables.
- Determine how the variables relate to each other in different math courses (i.e. geometry or 4<sup>th</sup> grade math).
- Increase the scope of the study to include other states with state assessments.
- Widen the range of school contexts to include urban, suburban, rural, high or low achieving
- Explore the characteristics of students and how this impacts teacher self-efficacy and achievement
- Explore how the level of student self-efficacy correlates to the teacher's level of self-efficacy and the student achievement.
- Expand the measures used to measure assessment to include other standard assessments or measures of progress.
- What is the relationship between teacher self-efficacy and student achievement in countries who may teach from a more conceptual bent (i.e. South Korea, Taiwan)?
- Develop a sample that contains teachers from a variety of self-efficacy ranges (high to low).
- Conduct longitudinal studies to determine if teacher self-efficacy and student achievement are correlated over time.

### **Mathematics Content Knowledge**

This study found that the level of a teacher's content knowledge did not impact the overall self-efficacy beliefs of the teacher nor the achievement of the students.

However, only one measure was used for this study. There is research that provides a link between these variables, so it would be beneficial to continue explore these relationships.

Primarily, it would be of interest to determine if the way that mathematics content knowledge is measured impacts the relationship between it, student achievement, and teacher self-efficacy and mathematics pedagogical knowledge. Some possible avenues for study could be:

- Investigate how the variables relate to each other in different math courses (i.e. geometry of fourth grade math)?
- Develop studies that have enhanced measures for content knowledge to shed light on the mixed results found with respect to this variable.
- Explore the relationship of these variables at the elementary level.

One of the most positive finds in this study was the positive correlation between teacher self-efficacy and the level of mathematics pedagogical knowledge a teacher reported. Improving the skills and knowledge of teachers can lead to higher self-efficacy beliefs in teachers. This will ultimately lead to more positive behaviors in the classroom that impact students. The question to ask is really happening in the classrooms of teachers with high self-efficacy beliefs? What are the specific behaviors teachers are being exhibiting by highly efficacious mathematics teachers? Do these behaviors lead to an improvement in student achievement? Possibilities for research could include ideas such as:

- Conduct qualitative interviews and classroom observations with teachers to determine what instructional strategies are being used with students in classroom where there are different levels of teacher efficacy and student achievement.
- What are the instructional strategies that lead to higher achievement in student in mathematics?
- What are the instructional strategies that would enhance math teacher's pedagogical knowledge?
- How do these variables relate to each other in different math courses (i.e. geometry or 4<sup>th</sup> grade math?

What makes teacher self-efficacy such a powerful construct is that it touches many, many aspects of teaching. It provides a plethora of avenues for research. What is important to glean from this study is that we need to keep researching the construct. Even though this study did not find a correlation between teacher self-efficacy and student achievement or mathematics content knowledge, it did find a powerful relationship between teacher self-efficacy and mathematics pedagogical knowledge. The more knowledge a teacher has in the area of pedagogy, the higher their self-efficacy. This may in turn lead to behaviors in the classroom that ultimately improve student learning. With each new study that is conducted, something new is learned that helps enhance the understanding of the complex art and science of teaching and provides new opportunities for school leaders to assist teachers in improving their practice.

### **Implications for Practice**

The ultimate purpose of educational research is to learn more about the complex art and science of teaching so as to improve student outcomes. School leaders should

invest in professional development for practicing teachers that highlight the pedagogy of teaching mathematics, and schools of education should provide additional mathematics methods courses for pre-service teachers.

As a teacher's knowledge for the pedagogy of teaching mathematics increases, so too does their self-efficacy for teaching mathematics. Teachers who have spent more time studying the pedagogical methods specific to a content area, typically have higher self-efficacy (Utley et al., 2005). Swars et al. (2007) indicated that the more methods courses a teacher took the higher the teacher's self-efficacy. There is a robust relationship between teacher self-efficacy and instructional strategies (Riggs & Enoch, 1990). Higher teacher self-efficacy has been linked in research to behaviors that lead to higher student achievement. Self-efficacy is a critical component of effective teaching and can increase student achievement (Tschannen-Moran et al., 1998).

Improving the mathematics pedagogical knowledge of teachers can increase their self-efficacy. Research indicates that teachers who are highly efficacious exhibit behaviors that have a positive impact on the classroom such as the amount of time they put into teaching, the goals they set, the level of accomplishment to which they aspire, a more positive attitudes toward teaching, and persistence they in the face of challenges (Ashton & Webb, 1986; Guskey, 1981; Tschannen-Moran et al., 1998). The mathematics teachers with high levels of self-efficacy in this study exhibited behaviors such as knowing how to use manipulatives such as algebra tiles; knowing how to use a graphing calculator; knowing how to explain Algebra vocabulary to students; and knowing how to group students in the class or differentiate based on student needs or knowledge.



Providing high quality, job-embedded, and on-going professional development for teachers is within the purview of school leaders. Schools of education have some control over the courses students are required to take. Departments of Education could require refresher methods courses for all teachers during a teacher's relicensure cycle. All of these options are also manageable from a resources standpoint.

### **Summary**

Today's schools have the unique challenge of preparing students for federal or state assessments that are used to determine accreditation; finding ways to help every student meet heightened graduation requirements; producing students who can compete in a global marketplace; and preparing students for life after formal education ends. The impact teachers and their beliefs have on student learning is both an interesting and powerful idea to investigate. While teacher self-efficacy has been shown to be related to student outcomes, such as student achievement (Armor et al., 1976; Ashton & Webb, 1986; Moore & Esselman, 1992; Ross, 1992), it was not found to be related to student achievement in this study. There is mixed feedback as to the relationship between teacher self-efficacy and mathematics content knowledge – evidenced by some studies that provide a correlation between the two and some studies that identify no relationship between the two.

Teacher self-efficacy impacts the teacher's behaviors, which in turn impact the teacher's performance in the classroom. It is this link between beliefs and actions that results in improvements in student outcomes. This study did find a strong correlation between teacher self-efficacy and mathematics pedagogical knowledge, informing us that

the more mathematics pedagogical knowledge a teacher possess the higher his or her self-efficacy will be.

Studying self-efficacy has opened the door to additional questions about the construct and how it interacts with other variables to influence teachers and students. The more we know about teacher self-efficacy, mathematics content knowledge, and mathematics pedagogical knowledge, the more we know about teachers and how their behaviors will ultimately impact the learning and achievement of students. In this current climate of high stakes testing and national mandates for student outcomes, self-efficacy is a construct that warrants our continued attention, focus and efforts.

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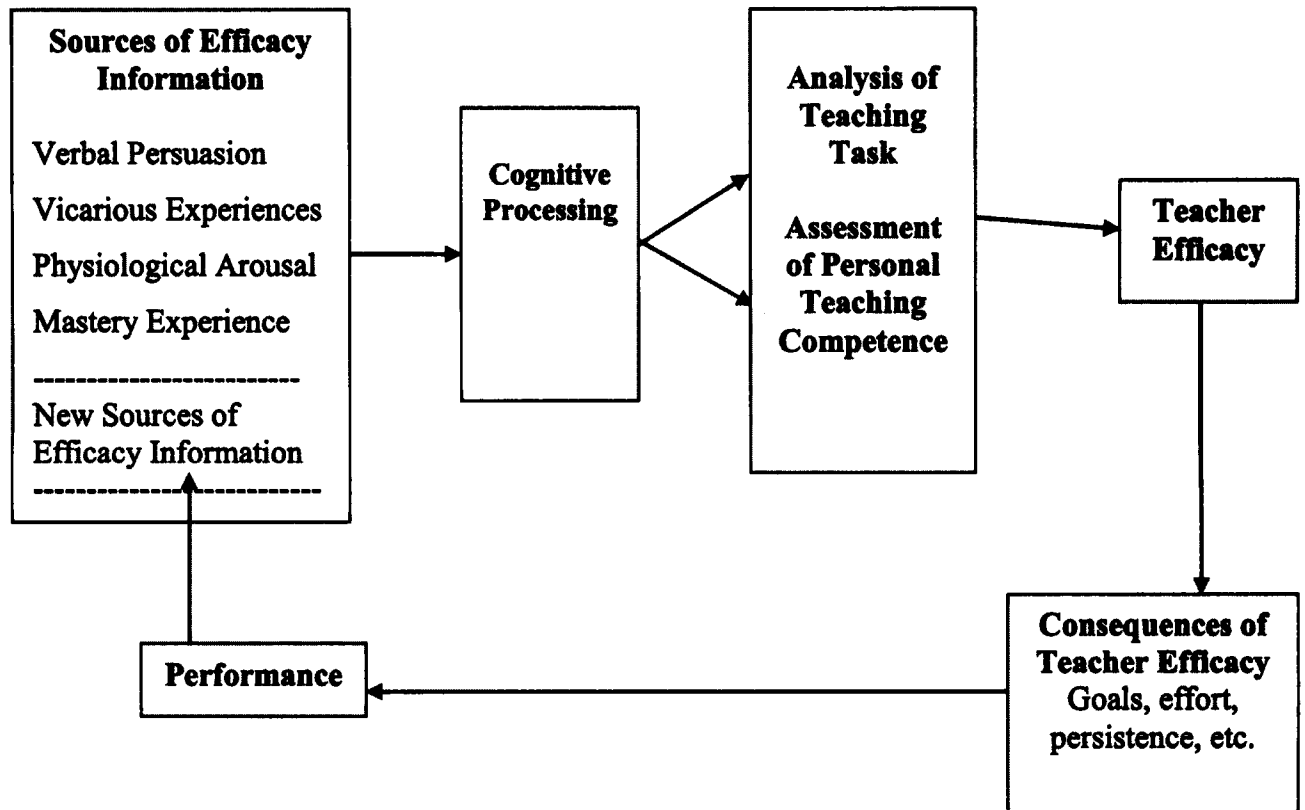
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Appendix A

The Cyclical Nature of Teacher Self-Efficacy



Source: Tschannen-Moran, Woolfolk Hoy & Hoy, 1998



## Appendix B

## Teacher Self-Efficacy Scale for Mathematics Instruction (TSESMI)

| <b>Directions</b>  |   |                     |   |                     |   |                     |   |                      |
|--|---|---------------------|---|---------------------|---|---------------------|---|----------------------|
| <b>PART 1: BELIEFS ABOUT TEACHING ALGEBRA</b>  |   |                     |   |                     |   |                     |   |                      |
| Please respond to the each of the questions by considering the combination of your current ability, resources, and opportunity to do each of the following in your present position. |   |                     |   |                     |   |                     |   |                      |
| <b>Response Choices</b>  |   |                     |   |                     |   |                     |   |                      |
| 1<br>Not At All  | 2   | 3<br>Very<br>Little | 4 | 5<br>Some<br>Degree | 6 | 7<br>Quite a<br>Bit | 8 | 9<br>A Great<br>Deal |
| <b>Question<br/>#</b>  | <b>Question</b>   |                     |   |                     |   |                     |   |                      |
| 1  | To what extent are students appropriately placed into Algebra?  |                     |   |                     |   |                     |   |                      |
| 2  | To what extent are students adequately prepared for Algebra?  |                     |   |                     |   |                     |   |                      |
| 3  | How much can you do to help your student's value learning Algebra?  |                     |   |                     |   |                     |   |                      |
| 4  | To what extent can you craft good questions for your Algebra students?  |                     |   |                     |   |                     |   |                      |
| 5  | How much can you do to teach students to create good algebraic proofs?  |                     |   |                     |   |                     |   |                      |
| 6  | How much can you do to help students believe they can do well in Algebra?   |                     |   |                     |   |                     |   |                      |
| 7  | To what extent do you use a variety of assessment strategies in Algebra?  |                     |   |                     |   |                     |   |                      |
| 8  | To what extent can you provide an alternate explanation or example when your students are confused?                               |                     |   |                     |   |                     |   |                      |
| 9  | To what extent can you assist families in helping their children do well in Algebra?  |                     |   |                     |   |                     |   |                      |
| 10   | How well can you implement alternative teaching strategies in Algebra?  |                     |   |                     |   |                     |   |                      |
| 11   | To what extent can you facilitate student questions and discussions during Algebra instruction?                                   |                     |   |                     |   |                     |   |                      |
| 12   | How much can you do to influence the achievement of students with low motivation in Algebra?                                      |                     |   |                     |   |                     |   |                      |
| 13   | How much can you do to influence the achievement of students who do computations, but don't understand the concept of a variable? |                     |   |                     |   |                     |   |                      |
| 14   | To what extent do you have the necessary content knowledge to teach Algebra well?   |                     |   |                     |   |                     |   |                      |
| 15   | To what extent do you have the necessary pedagogical (methods of teaching) knowledge to teach Algebra well?                       |                     |   |                     |   |                     |   |                      |
| 16   | To what extent do you have the necessary knowledge and skills to produce meaningful progress in Algebra for every student?        |                     |   |                     |   |                     |   |                      |
| 17   | To what extent do you base your Algebra instruction on a theoretical model of how students learn Algebra?                         |                     |   |                     |   |                     |   |                      |
| 18   | How much can you do to motivate students who show low interest in Algebra?  |                     |   |                     |   |                     |   |                      |
| 19   | How well can you explain to students how algebraic proofs work?   |                     |   |                     |   |                     |   |                      |

| <b>Directions</b>  |   |                     |                            |                           |
|--|---|---------------------|----------------------------|---------------------------|
| <b>PART 1 (Section 2): BELIEFS ABOUT TEACHING ALGEBRA CONTINUED.</b>   |   |                     |                            |                           |
| Please rate your level of knowledge in the following areas by circling the appropriate letter to the right of each statement |   |                     |                            |                           |
| <b>Response Choices</b>  |   |                     |                            |                           |
| <b>E</b><br>Excellent  | <b>AA</b><br>Above Average  | <b>A</b><br>Average | <b>BA</b><br>Below Average | <b>NK</b><br>No Knowledge |
| <b>Question #</b>  | <b>Question</b>   |                     |                            |                           |
| 20   | How would you rate your knowledge of the use of manipulatives such as Algebra tiles in the Algebra classroom?   |                     |                            |                           |
| 21   | How would you rate your knowledge of the use of the graphing calculator in the Algebra classroom?               |                     |                            |                           |
| 22   | How would you rate your capacity to explain Algebra vocabulary?   |                     |                            |                           |
| 23   | How would you rate your ability to make use of a variety of grouping practices in the Algebra classroom?        |                     |                            |                           |
| 24   | How would you rate your use of strategies to differentiate for varying levels of student knowledge and/or need? |                     |                            |                           |

| <b>Directions</b>   |  |                       |                   |                             |
|---|--|-----------------------|-------------------|-----------------------------|
| <b>PART 1 (Section 3): BELIEFS ABOUT TEACHING ALGEBRA CONTINUED.</b>  |  |                       |                   |                             |
| Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letter(s) to the right of each statement. |  |                       |                   |                             |
| <b>Response Choices</b>   |  |                       |                   |                             |
| <b>SD</b><br>Strongly Disagree  | <b>D</b><br>Disagree   | <b>U</b><br>Uncertain | <b>A</b><br>Agree | <b>SA</b><br>Strongly Agree |
| <b>Question #</b>   | <b>Question</b>  |                       |                   |                             |
| 25  | Students' achievement in Algebra is directly related to their teacher's effectiveness in Algebra teaching.                     |                       |                   |                             |
| 26  | The teacher is generally responsible for the achievement of students in Algebra.   |                       |                   |                             |
| 27  | Increased effort in Algebra teaching produces little changes in some students' Algebra achievement.                            |                       |                   |                             |
| 28  | The low Algebra achievement of some students cannot generally be blamed on their teachers.                                     |                       |                   |                             |
| 29  | The inadequacy of a student's Algebra background can be overcome by good teaching.   |                       |                   |                             |
| 30  | The use of manipulatives such as Algebra tiles contribute to effective Algebra teaching.                                       |                       |                   |                             |
| 31  | Specific instruction in Algebra vocabulary is an important part of effective Algebra teaching.                                 |                       |                   |                             |
| 32  | Student questions and discussion are an important part of effective Algebra instruction.                                       |                       |                   |                             |
| 33  | The use of graphing calculators contributes to effective Algebra teaching.   |                       |                   |                             |
| 34  | If students are underachieving in Algebra, it is most likely due to ineffective Algebra teaching.                              |                       |                   |                             |
| 35  | When the Algebra grades of students improve, it is often due to their teacher having found a more effective teaching approach. |                       |                   |                             |
| 36  | I am continually finding better ways to teach Algebra.   |                       |                   |                             |

| <b>Directions</b>                       |  |
|---|--|
| <b>PART 2 : FREE RESPONSE QUESTIONS</b> |  |
| <b>Question #</b>                       | <b>Question</b>  |
| 37                                      | Have the types of students you teach in Algebra changed in the last five years? If so, how?  |
| 38                                      | Please list the professional development activities you have participated in that helped improve your Algebra teaching.  |
| 39                                      | What specific topics or techniques would you suggest be included in professional development for improving your Algebra teaching?                              |
| 40                                      | Please rank order the activities you listed by putting a "1" next to the activity you feel would be the most beneficial, "2" by the next most beneficial, etc. |

| <b>PART 3: DEMOGRAPHIC INFORMATION</b> |  |
|--|--|
| <b>Question #</b>                      | <b>Question</b>  |
| 41                                     | What is your gender? (Male or Female)  |
| 42                                     | What is your racial identity? (African American, Hispanic, White, Non-Hispanic, Other)   |
| 43                                     | What level do you teach? (Middle, High)  |
| 44                                     | How many years have you taught?  |
| 45                                     | What school division do you teach in?  |
| 46                                     | What school do you teach in?   |
| 47                                     | What is your certification or endorsement (Please check all that apply)<br>Math 6-12<br>Algebra Add-on<br>Elementary K-8<br>Special Education<br>Provisional<br>Other (please list)                                  |
| 48                                     | Have you participated in grant sponsored professional development?   |
| 49                                     | Please list the courses you currently teach and the format in which they are taught; for example, Algebra I for 90 minutes each day for one semester or Geometry for 115 minutes every other day for the whole year. |
| 50                                     | What other courses have you taught in the past?  |
| 51                                     | Your Name  |

## Appendix C

Date

Dear Math Coordinator, Division Testing Coordinator, Director or Assistant Superintendent,

Greetings from the College of William and Mary. My name is Antonia Fox and I am currently the principal of Tabb Middle School in Yorktown, and I am writing to you to ask for your assistance with my doctoral dissertation study. During the 2009-2010 or 2010-2011 school year, math teachers from your division participated in a professional development program with the College of William and Mary through the Tidewater Team for Math Education professional development grant program. These teachers also participated in a research study looking at teacher self-efficacy and student achievement, as measured by the spring 2010 or spring 2011 End-of-Course Algebra I assessment.

I am completing my dissertation at William and Mary under the direction of Dr. Megan Tschannen-Moran, and in order to be able to complete my research I need the average scaled SOL scores for the Algebra I teachers in your division (see enclosure). Each school division that participated in the program agreed to share the SOL data for the teacher's Algebra I classes from the spring of 2010 or spring 2011 EOC Algebra I test. These data were sent to the research team at William and Mary, but are unfortunately no longer available to the research team due to complications with data storage. I am writing to request your assistance in obtaining these important data again.

Dr. Margie Mason, from the College of William and Mary, is the primary investigator in this research project. This project has been approved by the William and Mary Human Subjects Committee and your superintendent agreed to the release of the SOL information as a condition of the teachers participating in the professional development program with the College of William and Mary during the 2009-2010 or 2010-2011 school year. To ensure that I follow the established requirements of the Human Subjects committee, a third party will be correlating the SOL scores received from you with the teacher's self-efficacy scores from the survey they completed in the spring of 2010 or the spring of 2011. I will only see a number (assigned randomly to each teacher) with an efficacy score and an SOL mean score. I will never know what any particular teacher's SOL scores were. At no time will teacher's names, student's names, or SOL scores be used in the dissertation. All results will be reported only as statistical relationships between variables.

Specifically, I am asking that you assist me by providing the spring of 2010 or spring of 2011 EOC Algebra I average scaled scores for the teachers listed in the accompanying document. I only need the average scaled score for 2010 or 2011 EOC Algebra I test for the teacher(s) listed (all student scores for the teacher divided by the number of students who took the test). If you do not have time to compute the average scaled score or cannot find it easily, you can forward the student scores, sans student names, and we will compute the mean for the teacher.

There are several ways that you can provide this data:

1. Send it in hard-form using the table that is included with this letter to Dr. Megan Tschannen-Moran, College of Williams & Mary, School of Education, PO Box 8795, Williamsburg, VA 23187-8795;
2. Send it electronically to Dr. Megan Tschannen-Moran ([mxtsch@wm.edu](mailto:mxtsch@wm.edu));
3. Or call Dr. Megan Tschannen-Moran with this information and leave a voice mail message (phone number).

Time is of the essence in this study so I ask that you please respond by (date). If you have questions, please do not hesitate to contact Dr. Tschannen-Moran at the number above or myself at (phone number).

Thank you in advance for your assistance. I greatly appreciate it.

Sincerely,

Antonia M. Fox  
Doctoral Candidate at the College of William and Mary